



Biological Assessment Study

**Town Branch/Piper Creek
Polk County**

2015 - 2016

Prepared for:

**Missouri Department of Natural Resources
Division of Environmental Quality
Water Protection Program
Water Pollution Control Branch**

Prepared by:

**Missouri Department of Natural Resources
Division of Environmental Quality
Environmental Services Program
Water Quality Monitoring Section**

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ATTACHMENTS

Appendix A	Piper Creek and Town Branch Macroinvertebrate Taxa Lists
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1.0 Introduction

At the request of the Missouri Department of Natural Resources (**the department**) Water Protection Program (**WPP**), the Environmental Services Program (**ESP**) Water Quality Monitoring Section (**WQMS**) conducted a biological assessment of Piper Creek and Town Branch, a tributary of Piper Creek, in Polk County, Missouri. A 0.5-mile reach of Town Branch downstream of the Bolivar Wastewater Treatment Facility (**WWTF**) was originally added to the 303(d) list in 2002 for high levels of volatile suspended solids (**VSS**). A 7.5-mile reach of Piper Creek was added to the 2004/2006 and 2008 303(d) lists for organic sediment and unknown pollutants. The listed Piper Creek segment included Town Branch downstream of the Bolivar WWTF and Piper Creek downstream of Town Branch to the confluence with the Pomme de Terre River. A TMDL was developed in 2010 for Town Branch and Piper Creek (U.S. EPA 2010).

1.1 Study Area/Justification

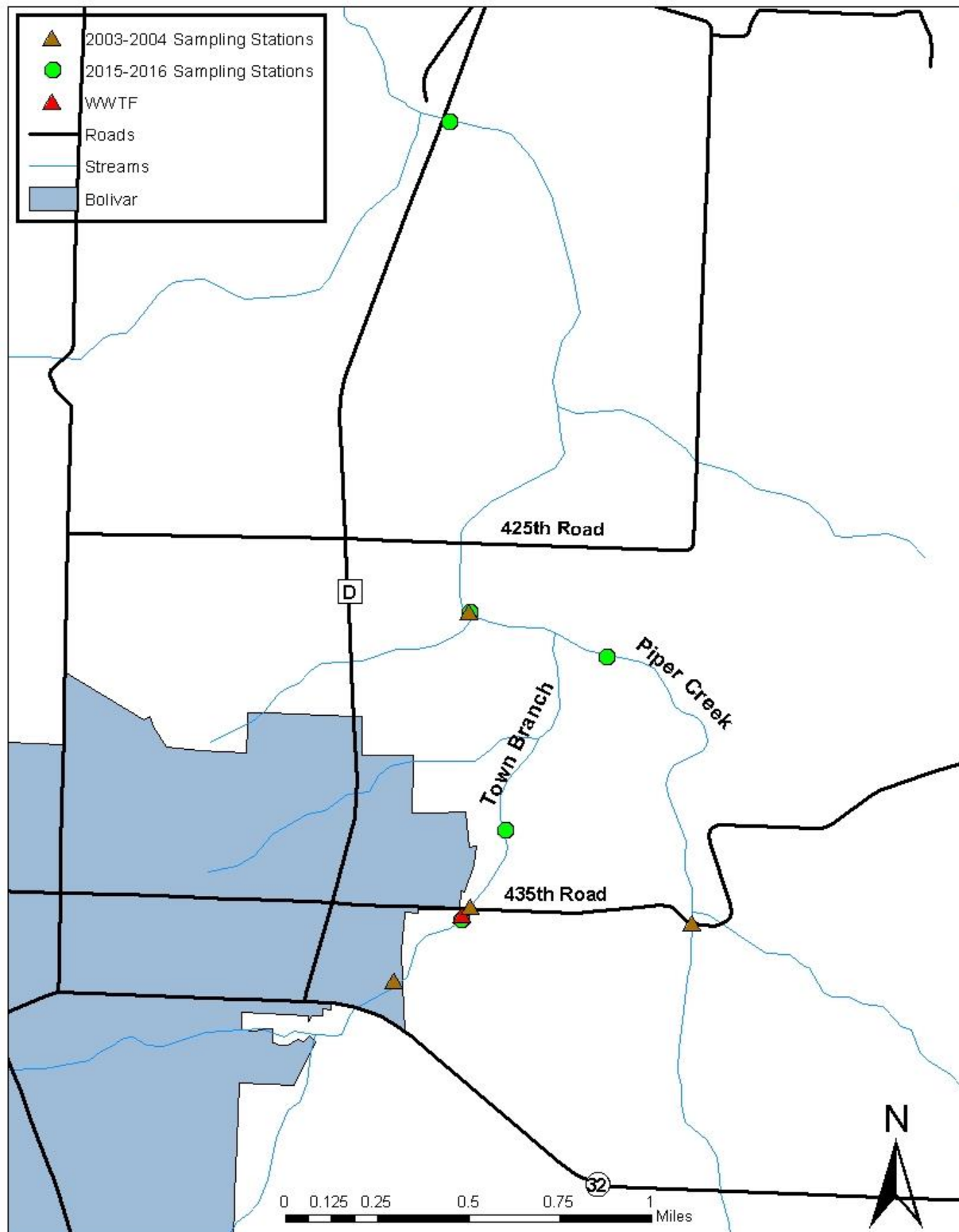
Town Branch, a tributary of Piper Creek, originates in Polk County within the city limits of Bolivar, and Piper Creek originates in Polk County just south of Bolivar. According to the Missouri Water Quality Standards (**WQS**, MoDNR 2014a), Town Branch is listed as class “P” for 2.5 miles starting near Highway 83 to the confluence into Piper Creek. Piper Creek is listed in the WQS as a class “P” stream for 5.3 miles starting downstream of Town Branch to the Pomme de Terre River confluence (Figure 1). Piper Creek has a class “C” designation upstream of Town Branch. Designated uses for the class “P” section of Piper Creek and Town Branch are “warm water aquatic life protection, human health/fish consumption, livestock and wildlife watering, and class B whole body contact recreation.”

A biological assessment study was conducted during the fall 2003 and spring 2004 sampling seasons at four stations (MoDNR 2005). The study had two control stations and two test stations on Town Branch and Piper Creek that bracketed the Bolivar WWTF. The results of the study found that the macroinvertebrate community was impaired at all stations during both sampling seasons compared to the Ozark/Osage Ecological Drainage Unit (**EDU**) biological criteria and small candidate reference stream criteria. Macroinvertebrate Stream Condition Index (**MSCI**) scores ranged from 8 to 14 (Tables 12 and 13).

Town Branch was originally placed on the 303(d) list because the Bolivar WWTF had a history of depositing organic sediment or sludge on the stream bottom. Recently, the Bolivar WWTF was upgraded to reduce the amount organic sediment on the stream bottom and improve the water quality in Town Branch and Piper Creek.

Because Town Branch and Piper Creek are smaller than the wadeable/perennial biological criteria reference (**BIOREF**) stream segments used to calculate criteria thresholds for the Ozark/Osage EDU, the stream was assessed for this study using two sets of biological criteria. Macroinvertebrate samples for all sites were first compared to the Ozark/Osage EDU biological criteria for wadeable/perennial streams. Samples also were compared to small candidate reference stream criteria to address potential macroinvertebrate community effects due to stream

Figure 1
Map of Town Branch, Piper Creek, and Sampling Stations in 2003-2004 and 2015-2016



size. The streams used to calculate candidate reference stream criteria included four streams (Barren Fork, Deer Creek, Macks Creek, and Starks Creek) that were sampled for the 2002-2003 Little Lindley Creek biological assessment study (MoDNR 2003), one stream (Dry Fork) that was sampled for the 2003-2004 Town Branch/Piper Creek biological assessment study (MoDNR 2005), and Ingalls Creek, a control stream sampled for the 2011-2012 Little Lindley Creek study (MoDNR 2013). The Valley Segment Type (**VST**) five-digit codes developed by the Missouri Resource Assessment Program (**MoRAP**) were used in the selection of candidate reference stream segments (Sowa et al. 2004). These streams were chosen from a list of streams that had the same or a very similar five-digit VST code as the test streams and had little or no observable water quality problems in their watersheds. Candidate reference streams chosen for this study were required to meet the same conditions as BIOREF streams as described in *Biological Criteria for Wadeable/Perennial Streams of Missouri* (MoDNR 2002).

1.2 Purpose

The purpose of the study is to reassess Town Branch and Piper Creek to determine if the macroinvertebrate community has changed since the completion of the Bolivar WWTF upgrades and compare current results to the 2003-2004 study.

1.3 Objectives

- 1) Determine if the Town Branch and Piper Creek macroinvertebrate communities are impaired compared to biological criteria developed from BIOREF stream data in the Ozark/Osage EDU.
- 2) Determine if the Town Branch and Piper Creek macroinvertebrate communities are impaired compared to criteria developed from candidate reference streams in the Ozark/Osage EDU.
- 3) Assess the habitat quality of Town Branch and Piper Creek.

1.4 Tasks

- 1) Conduct a bioassessment of the macroinvertebrate community on two Town Branch sampling stations and three Piper Creek sampling stations during the fall 2015 and spring 2016 sampling seasons.
- 2) Collect water samples and *in situ* water quality field measurements on two Town Branch sampling stations and three Piper Creek sampling stations during the fall 2015 and spring 2016 sampling seasons.
- 3) Conduct a habitat assessment at the sampling stations to ensure comparability of aquatic habitats.

1.5 Null Hypotheses

- 1) The macroinvertebrate community will not differ among longitudinally separate reaches of Town Branch and Piper Creek.

- 2) The macroinvertebrate assemblages in the Town Branch and Piper Creek samples will be similar to the Ozark/Osage EDU wadeable/perennial stream biological criteria.
- 3) The macroinvertebrate assemblages in the Town Branch and Piper Creek samples will be similar to the Ozark/Osage EDU candidate reference stream criteria.
- 4) Physicochemical water quality from Town Branch and Piper Creek will meet the WQS of Missouri (MoDNR 2014a).
- 5) Physicochemical water quality will not differ among longitudinally separate reaches of Town Branch and Piper Creek.
- 6) Stream habitat at the Town Branch and Piper Creek sampling stations will be similar to Dry Fork, a candidate reference stream in the Ozark/Osage EDU.

2.0 Methods

Carl Wakefield, Brandy Bergthold, Brian Nodine, and Rachel Heth of the Missouri Department of Natural Resources, Division of Environmental Quality, Environmental Services Program, Water Quality Monitoring Section conducted this study.

2.1 Study Timing

Macroinvertebrate and water samples were collected at the Town Branch and Piper Creek sampling stations during the fall 2015 and spring 2016 sampling seasons. Fall sampling was conducted on September 21-22, 2015, and spring sampling was conducted on March 15, 2016.

2.2 Station Descriptions

The study area and sampling locations for the Town Branch and Piper Creek biological assessment study are shown in Figures 1 and 2. A total of two Town Branch and three Piper Creek test stations were surveyed for this study. Three of the four sampling stations for the 2003-2004 study were moved to different locations for this study. Both of the Town Branch sampling stations were moved downstream slightly because the WWTF effluent discharge location was moved downstream. The upstream Piper Creek control station was moved to a downstream location because the original sampling station was located in a cattle pasture, which affected stream habitat quality within the sampling reach. A downstream Piper Creek station was also added to this study to assess water quality conditions farther downstream.

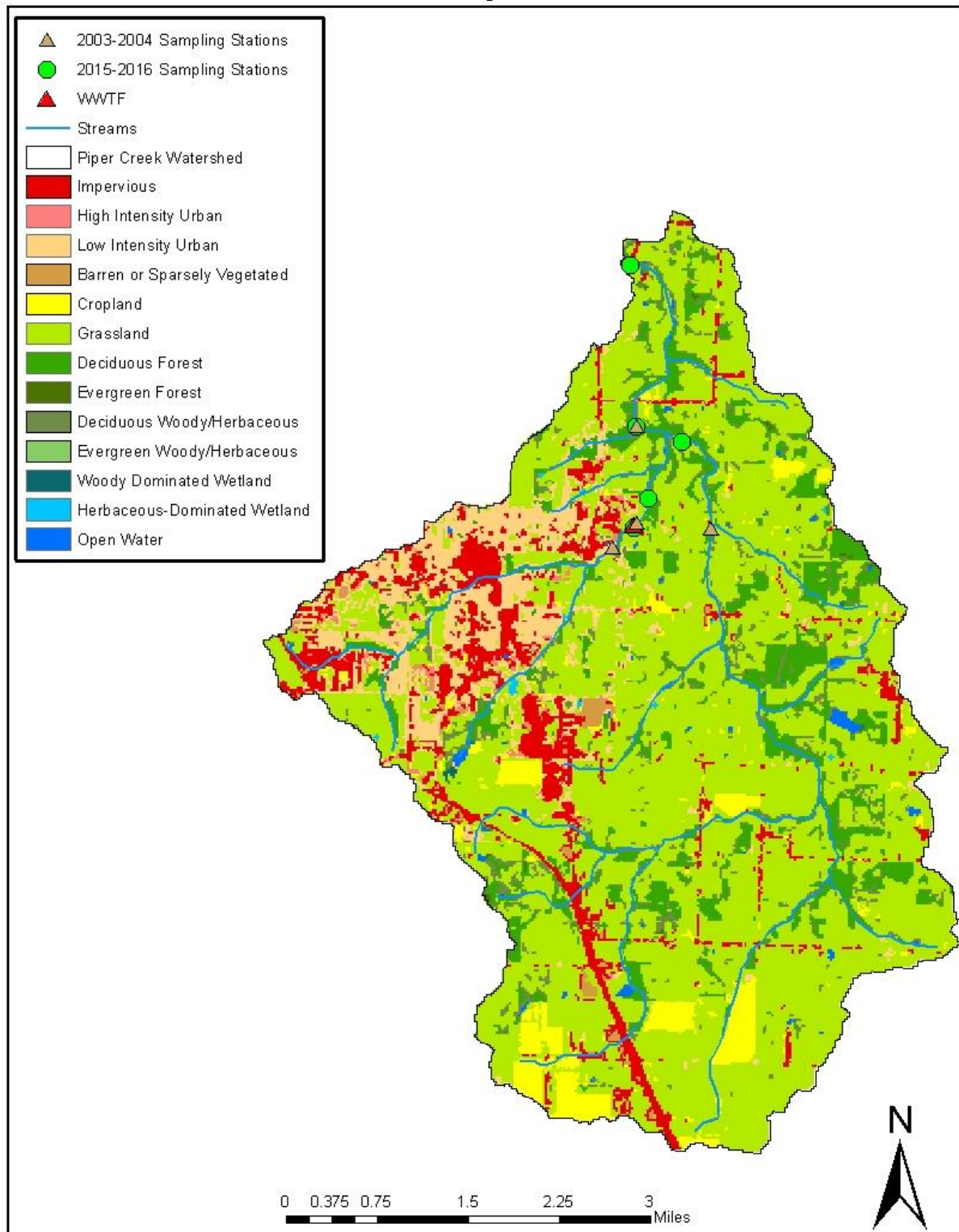
2.2.1 Town Branch/Piper Creek Biological Assessment Sampling Stations

All Town Branch and Piper Creek sample stations were located in Polk County, Missouri.

Piper Creek #0.5 (N 1/4, Sec. 30, T. 34 N., R. 22 W.) was located upstream of Highway D. Geographic coordinates are UTM zone 15, 465756 Easting, 4167078 Northing.

Piper Creek #1 (SW ¼ Sec. 31, T. 34 N., R. 22 W.) was located upstream of the 425th Road crossing. Geographic coordinates are UTM zone 15, 465845 Easting, 4164898 Northing.

Figure 2
Land Cover of the Piper Creek Watershed



Piper Creek #1.5 (SW ¼ Sec. 31, T. 34 N., R. 22 W.) was an upstream control station located near South 137th Road. Geographic coordinates are UTM zone 15, 466447 Easting, 4164697 Northing.

Town Branch 0.9 (SW ¼ Sec. 6, T. 33 N., R. 22 W.) was located approximately 0.3 miles downstream of the Bolivar WWTF outfall. Geographic coordinates are UTM zone 15, 466004 Easting, 4163928 Northing.

Town Branch 1.1 (NW ¼ Sec. 6, T. 33 N., R. 22 W.) was a control station located upstream of the Bolivar WWTF outfall. Geographic coordinates are UTM zone 15, 465811 Easting, 4163534 Northing.

2.2.2 Candidate Reference Bioassessment Sampling Stations

Barren Fork #1 – Miller County (Sec. 16, T. 39 N., R. 13 W.) was located upstream of Ponder Slab Road. Geographic coordinates were UTM zone 15, 0556263 Easting, 4218902 Northing.

Deer Creek #1 – Benton County (NE ¼ Sec. 30, T. 40 N., R. 20 W.) was located approximately 0.75 miles downstream of State Highway V. Geographic coordinates were UTM zone 15, 0485011 Easting, 4229279 Northing.

Dry Fork #1 – Polk County (SW ¼ Sec. 35, T. 35 N., R. 23 W.) was located upstream of Highway 83. Geographic coordinates were UTM zone 15, 0460915 Easting, 4177151 Northing.

Ingalls Creek #1 – Hickory County (SE ¼, NW ¼ Sec. 4, T. 35 N., R. 21 W.) was located upstream of County Road 351. Geographic coordinates were UTM zone 15, 0477728 Easting, 4184897 Northing.

Macks Creek #1 – Camden County (Sec. 29, T. 38 N., R. 19 W.) was located upstream of Coffey Hollow Road. Geographic coordinates were UTM zone 15, 0496640 Easting, 4206301 Northing.

Starks Creek #1 – Hickory County (Sec. 23, T. 38 N., R. 20 W.) was located downstream of County Road 501 within the Mule Shoe Missouri Department of Conservation Area. Geographic coordinates were UTM zone 15, 0491250 Easting, 4208246 Northing.

2.3 MoRAP Aquatic Ecological Classification

The aquatic ecological classification developed by MoRAP is a classification system that divides the aquatic resources of Missouri into distinct regions. It has seven levels of classification starting at large regions and then dividing them into smaller sub-regions (Sowa et al. 2004). The following are the seven levels of classification in hierarchical order: zone, subzone, region, aquatic sub-regions, EDU, Aquatic Ecological Systems (AES), and Valley Segment Types (VST). The levels of classification are based on biology, zoogeography, taxonomic composition, geology, soils, and groundwater connection. Some levels of the hierarchical system use geology and soils to classify, whereas other levels use biology and taxonomic composition of aquatic

communities. EDU, AES, and VST are the three levels of classification that will be assessed in detail for this study.

2.3.1 Ecological Drainage Unit

The EDU is level five of the classification hierarchy and is based on geographical variation of the taxonomic composition of the level four sub-regions. An EDU is a region in which aquatic biological communities and habitat conditions can be expected to be similar. Town Branch and Piper Creek are located within the Ozark/Osage EDU.

2.3.2 Aquatic Ecological Systems

Aquatic Ecological Systems are level six of the classification hierarchy. They classify aquatic systems based on geology, soils, landform, and groundwater influence. Town Branch and Piper Creek are located in the Boeuf Creek AES type (Sowa and Diamond 2006). Local relief for the Boeuf Creek AES type is variable and ranges from nearly 50 to 200 feet. Bedrock geology is dominated by Ordovician Jefferson City-Cotter formation cherty dolomites, although sandstone and limestone are occasionally present. There are some sinkholes, but they are not common in most areas of this AES type. Surface soil textures consist of silty loams or occasionally cherty soils and tend to have slow to moderate infiltration rates. Spring influence is variable and is not as characteristic as other Ozark AES types. Historic vegetation consisted of oak savanna, woodlands, and smaller amounts of prairie and glades.

2.3.3 Valley Segment Types

Valley Segment Types are level seven of the classification hierarchy. Stream segments in the GIS stream network layer are classified using a five-digit code. The five-digit VST code is based on temperature regime, stream size, flow regime, geology, and relative gradient. The 5-digit VST codes and the values for the five parameters making up the codes can be found in Table 1.

2.4 Land Cover

Land cover percentages were determined using the Missouri portion of the MoRAP Thematic Mapper satellite data from 2000 to 2004. Land cover percentages were determined for the entire Ozark/Osage EDU, Town Branch and Piper Creek sampling stations, and Dry Fork, a candidate reference stream located in Polk County.

2.5 Habitat Assessment

A standardized assessment procedure was followed as described for riffle/pool habitat in the *Stream Habitat Assessment Project Procedure (SHAPP)* (MoDNR 2016i). Habitat assessments were conducted at the two Town Branch test stations, three Piper Creek test stations, and Dry Fork, a candidate reference stream, on September 21 and 22, 2015.

2.6 Biological Assessment

Biological assessments consisted of macroinvertebrate collection and physicochemical sampling for the two sample periods.

2.6.1 Macroinvertebrate Collection and Analysis

A standardized macroinvertebrate sample collection and analysis procedure was followed as described in the *Semi-quantitative Macroinvertebrate Stream Bioassessment Project Procedure (SMSBPP)* (MoDNR 2012a) for riffle/pool (**RP**) streams. Three standard habitats—flowing water over coarse substrate (**CS**), depositional substrate in non-flowing water (**NF**), and rootmat (**RM**)—were collected at the sampling stations.

Macroinvertebrate data were analyzed using three methods. The first analysis was to calculate the Macroinvertebrate Stream Condition Index (**MSCI**) using the four general biological metrics found in the SMSBPP (MoDNR 2002, MoDNR 2012a). These four biological metrics included: 1) Taxa Richness (**TR**); 2) Ephemeroptera/Plecoptera/Trichoptera Taxa (**EPTT**); 3) Biotic Index (**BI**); and 4) Shannon Diversity Index (**SDI**). These individual metrics were scored by comparing them to BIOREF streams from the Ozark/Osage EDU and combined to form the MSCI. MSCI scores of 16-20 qualify as fully supporting, 10-14 are partially supporting, and 4-8 are considered non-supporting of the protection of warm water aquatic life beneficial use designation as specified in the Missouri Water Quality Standards (MoDNR 2014a).

The second analysis was calculating MSCI scores using macroinvertebrate data collected at candidate reference streams from the Ozark/Osage EDU using the same four metrics listed above. This analysis was conducted to determine the extent to which stream size affected the macroinvertebrate community since the Piper Creek and Town Branch sampling stations were much smaller than the wadeable/perennial BIOREF streams used to calculate biological criteria for the Ozark/Osage EDU.

The third analysis was an evaluation of macroinvertebrate community composition using percent composition of EPTT, sensitive taxa, and dominant macroinvertebrate families and taxa. Comparisons of the macroinvertebrate community of Town Branch, Piper Creek, and the BIOREF streams also were made.

2.7 Physicochemical Data Collection and Analysis

2.7.1 *In situ* Water Quality Measurements

During each sampling period, *in situ* water quality measurements were collected at each of the bioassessment sampling stations. Field measurements included water temperature (°C) (MoDNR 2016c), dissolved oxygen (mg/L) (MoDNR 2016e), conductivity (µS/cm) (MoDNR 2016d), and pH (MoDNR 2012b).

2.7.2 Water Chemistry

Surface water grab samples were collected and returned for analyses to ESP. Turbidity (NTU) (MoDNR 2016b) was measured and recorded in the ESP WQMS biology laboratory. Water samples were analyzed by ESP's Chemical Analysis Section for total suspended solids, chloride, sulfate, total calcium, total magnesium, total phosphorus, ammonia-N, nitrate+nitrite-N, and total nitrogen. Procedures outlined in *Required/Recommended Containers, Volumes, Preservatives*,

Table 1
Physical Characteristics of the Sampling Reaches for Piper Creek and Town Branch Based on Values from the MoRAP Valley
Segment Types (VST) Geographic Information Systems (GIS) Layer and Other GIS Sources

	Piper Creek #0.5	Piper Creek #1	Piper Creek #1.5	Town Branch #0.9	Town Branch #1.1
Watershed Area (mi ²)	22.0	22.0	15.9	5.2	5.2
Strahler Order	3	3	3	2	2
Link Magnitude	14	13	8	3	3
VST 5 Digit Code	22121	22121	22121	21121	21121
Temperature Regime	Warm	Warm	Warm	Warm	Warm
Stream Size	Creek	Creek	Creek	Headwater	Headwater
Flow Regime	Permanent	Permanent	Permanent	Permanent	Permanent
Geology	Limestone	Limestone	Limestone	Limestone	Limestone
Relative Gradient	Low	Low	Low	Low	Low

Holding Times, and Special Sampling Considerations [Standard Operating Procedure (SOP) MDNR-ESP-001 (MoDNR 2016a)] and *Field Sheet and Chain-of-Custody Record* [SOP MDNR-ESP-002 (MoDNR 2014b)] were followed when collecting water quality samples. Stream velocity was measured at each station using a SonTek/YSI FlowTracker Handheld-ADV (Acoustic Doppler Velocimeter). Discharge was calculated per the methods in SOP MDNR-ESP-113, *Flow Measurement in Open Channels* (MoDNR 2015b).

2.7.3 Data Analysis

Physicochemical data were examined by analyte to determine whether stations had violations of the Missouri WQS. Sampling stations that had values not in compliance with the WQS or U.S. Environmental Protection Agency (U.S. EPA) recommended reference values will be discussed in the report with possible influences being identified.

2.8 Quality Assurance/Quality Control (QA/QC)

2.8.1 Field Meters

All field meters used to collect water quality parameters were maintained in accordance with the Standard Operating Procedure MDNR-ESP-213, *Quality Control Procedures for Checking Water Quality Field Instruments* (MoDNR 2016g).

2.8.2 Biological Samples

Steps to assure accuracy of organism removal from sample debris were performed consistent with those methods found in the SMSBPP document (MoDNR 2012a). Macroinvertebrates found in samples were identified to the taxonomic levels found in Standard Operating Procedure MDNR-ESP-209, *Taxonomic Levels for Macroinvertebrate Identification* (MoDNR 2016f).

2.8.3 Biological Data Entry

All macroinvertebrate data were entered into the WQMS macroinvertebrate database consistent with the Standard Operating Procedure MDNR-ESP-214, *Quality Control Procedures for Data Processing* (MoDNR 2016h).

2.8.4 Duplicate Sample Collection

Duplicate samples are collected at two randomly selected sampling stations per season for macroinvertebrates and for 10 percent of water samples. Macroinvertebrate and water duplicate samples were collected at Piper Creek #1 during the spring 2016 sampling season.

3.0 Analyses and Results

3.1 Land Cover

Land cover analysis showed that the Piper Creek and Town Branch test stations had higher percentages of impervious surface, high intensity urban, low intensity urban, and grassland, but a lower percentage of forest compared to the Ozark/Osage EDU overall and Dry Fork, a candidate reference stream (Table 2 and Figure 2). Town Branch had much higher percentages of impervious surface and low intensity urban land cover compared to reference conditions. Dry Fork, a candidate reference stream in the Ozark/Osage EDU, was used as the reference condition comparison for stream habitat and land cover.

Table 2
Percent Land Cover from MoRAP Thematic Mapper Satellite Data from 2000 to 2004

Land Cover	Ozark/Osage EDU	Dry Fork #1	Piper Creek #0.5	Piper Creek #1	Piper Creek #1.5	Town Branch #0.9	Town Branch #1.1
Impervious	1.2	1.5	8.4	8.7	5.0	20.1	20.1
High Intensity Urban	0.04	0.2	0.5	0.6	0.1	2.1	2.1
Low Intensity Urban	1.0	--	8.0	8.7	1.1	30.5	30.5
Barren/Sparsely Vegetated	0.5	0.4	0.8	0.8	0.7	1.2	1.2
Cropland	4.8	1.2	4.5	4.8	5.8	2.6	2.6
Grassland	43.0	47.2	62.6	61.7	71.2	33.5	33.5
Deciduous Forest	38.6	40.2	9.9	9.7	10.7	5.7	5.7
Evergreen Forest	1.4	1.1	0.1	0.1	0.1	2.8	2.8
Deciduous Woody/Herbaceous	4.8	7.5	4.4	4.2	4.6	0.1	0.1
Evergreen Woody/Herbaceous	0.05	0.2	0.01	0.01	0.01	--	--
Woody Dominated Wetland	0.7	0.02	0.03	0.03	--	--	--
Herbaceous- Dominanted Wetland	0.2	<0.01	0.1	0.1	0.1	0.2	0.2
Open Water	3.7	0.3	0.6	0.6	0.6	0.5	0.5

3.2 Stream Habitat Assessment

Table 3 provides habitat assessment scores for the Piper Creek, Town Branch and Dry Fork sampling stations. SHAPP guidance states that test stations scoring at least 75 percent of the total score of a reference station should support a similar biological community. Because Piper Creek and Town Branch stream habitat assessment scores were ≥ 75 percent of the reference score of Dry Fork, a candidate reference stream, the sampling stations should be capable of supporting a similar macroinvertebrate community.

Many of the habitat metric scores at the sampling stations were either in the optimal or suboptimal range, indicating good habitat quality. Some metrics, however, did not score as well. At Piper Creek #0.5, epifaunal substrate, velocity/flow regime, riffle quality, and vegetative protection for both banks scored in the marginal category, and right bank riparian zone width scored in the poor category. Bedrock was prevalent at Piper Creek #0.5, which affected habitat scores for epifaunal substrate and riffle quality. The other two Piper Creek stations generally had good habitat quality except for poor vegetative bank protection scores at both stations and marginal scores for channel flow status and riffle quality at Piper Creek #1.5. Like Piper Creek #0.5, bedrock was very abundant at Town Branch #0.9 and had some effect on the stream habitat results at this station. Epifaunal substrate, velocity/depth regime, and riffle quality scored in the marginal category, and vegetative bank protection scored in the poor category for both banks at Town Branch #0.9. At Town Branch #1.1, some bedrock was present in the uppermost pool of the sampling reach, but it was not nearly as abundant as Piper Creek #0.5 and Town Branch #0.9. Epifaunal substrate, channel flow status, riffle quality, and vegetative protection for both banks scored in the marginal category, and riparian zone width scored in the poor category for both banks at Town Branch #1.1.

3.3 Macroinvertebrate Biological Assessment

3.3.1 Semi-quantitative Macroinvertebrate Stream Bioassessment Project Procedure

MSCI scores were calculated for the Piper Creek and Town Branch sampling stations using BIOREF criteria and candidate reference criteria for the Ozark/Osage EDU (Tables 4 and 5). During the fall 2015 sampling season, all of the stations except Piper Creek #1.5 (upstream control) had MSCI scores in the partial support category when compared to both criteria datasets. MSCI scores ranged from 10 to 18 when compared to the BIOREF criteria and from 10 to 16 using the candidate reference criteria. Although the actual MSCI changed at two stations during the fall 2015 sampling season, both data sets resulted in MSCI scores that were in the same support category. The Piper Creek #1 MSCI score increased from 12 to 14 and the Piper Creek #1.5 MSCI score decreased from 18 to 16 when compared to the candidate reference criteria. During the spring 2016 sampling season, the candidate reference criteria values were higher for all metrics except BI, which led to a lower MSCI score at Piper Creek #0.5.

During the fall 2015 sampling season, all stations except Piper Creek #1.5 had taxa richness (TR) and EPTT metric scores in the partially or non-supporting range, compared to both criteria datasets. During both sampling seasons, TR was much lower at Town Branch than Piper Creek. The number of EPTT also was lower at Town Branch than Piper Creek during the fall 2015

Table 3

Predominant Category Habitat Values, Category Habitat Scores, Total Habitat Scores, and Percent of Reference SHAPP Values from Stream Habitat Assessments for Piper Creek and Town Branch Sampling Stations and Dry Fork, a Candidate Reference Stream

Stream Habitat Parameters	Piper Creek #0.5	Piper Creek #1	Piper Creek #1.5	Town Branch #0.9	Town Branch #1.1	Dry Fork #1
Macroinvertebrate Sample Number	15133	15134	15135	15136	15137	--
Stream Habitat Assessment Date	09/21/2015	09/21/2015	09/21/2015	09/21/2015	09/22/2015	09/22/2015
Epifaunal Substrate/Available Cover	III (7)	I (17)	II (15)	III (6)	III (9)	II (15)
Embeddedness	I (16)	I (16)	I (18)	I (18)	I (18)	I (18)
Velocity/Depth Regime	III (10)	I (16)	I (16)	III (6)	II (15)	III (8)
Sediment Deposition	II (19)	II (14)	II (15)	II (15)	II (14)	II (14)
Channel Flow Status	II (13)	II (12)	III (9)	II (14)	III (9)	III (8)
Channel Alteration	I (19)	I (20)	I (20)	I (20)	I (20)	I (20)
Riffle Quality	III (8)	II (15)	III (10)	III (6)	III (10)	III (8)
Bank Stability – Left Bank	I (10)	I (9)	I (10)	I (10)	I (10)	I (9)
Bank Stability – Right Bank	I (10)	I (9)	I (9)	I (10)	I (10)	I (10)
Vegetative Protection – Left Bank	III (3)	IV (1)	IV (1)	IV (2)	III (5)	IV (1)
Vegetative Protection – Right Bank	III (2)	IV (1)	IV (2)	IV (2)	III (5)	IV (2)
Riparian Zone Width – Left Bank	I (9)	I (10)	II (7)	I (10)	IV (1)	I (9)
Riparian Zone Width – Right Bank	IV (1)	I (9)	I (10)	II (7)	IV (1)	I (10)
Total Habitat Score	127	149	142	126	127	132
Percent of Reference Score	96.2	112.9	107.6	95.5	96.2	--

Habitat parameter categories range from I to IV with category I = optimal, category II = suboptimal, category III = marginal, and category IV = poor. Habitat parameter scores are listed in parentheses and range from 0 to 20 except for vegetative protection and riparian zone categories, which range from 0 to 10.

sampling season. Biotic Index scored in the partially supporting category for most samples compared to both datasets. The only exception was at Piper Creek #0.5 during the fall 2015 sampling season, which had a fully supporting BI score using BIOREF criteria. Compared to BIOREF data, SDI values were usually in the partially supporting range during both sampling seasons. The only exceptions were Piper Creek #1.5 during both sampling seasons and Piper Creek #0.5 during the fall 2015 sampling season. When compared to candidate reference stream criteria, most of the fall 2015 samples had SDI scores in the fully supporting range. The only exception was at Town Branch #0.9, which had an SDI score in the partially supporting range. During the spring 2016 sampling season, most SDI scores were in the partially supporting range compared to candidate reference streams. The only exception was at Piper Creek #1.5, which had an SDI value in the fully supporting range.

3.3.2 Macroinvertebrate Percent and Community Composition

The percent composition of sensitive taxa, FFG, EPTT, and the five dominant macroinvertebrate families and taxa at each station are presented in Figures 3 through 6 and Tables 6 through 9. Values in bold type represent the five dominant macroinvertebrate families and taxa for each station.

3.3.2.1 Fall 2015 Sampling Season

Percent Composition of Sensitive Taxa

Taxa found in Piper Creek and Town Branch samples were generally more tolerant of organic pollution than those taxa of BIOREF streams (Figure 3 and Table 6). The percentage of Piper Creek and Town Branch samples made up of taxa with BI values ≥ 5.0 was higher compared to reference conditions. These samples also had lower percentages of taxa with BI values < 5.0 . The percentage of taxa from Piper Creek and Town Branch stations with BI values ≥ 5.0 ranged from about 87 percent at Piper Creek #1.5 (upstream control) to about 97 percent at Piper Creek #0.5, compared to 79 percent at BIOREF streams. Most taxa found in Piper Creek and Town Branch samples with BI values ≥ 5.0 had values in the moderately tolerant range (BI=5.0-7.4). The percentage of taxa found in the Piper Creek and Town Branch samples with BI values < 5 were generally much lower than reference conditions. The only exceptions were at the upstream control station on Town Branch (station #1.1) and the upstream control of Piper Creek (station #1.5), both of which had percentages of taxa in the intolerant range (BI=2.5-4.9) that were slightly lower than reference conditions. However, these samples had much lower percentages of taxa in the very intolerant range (BI < 2.5) compared to references.

Percent Composition of Functional Feeding Groups (FFG)

Filterers, gatherer-collectors, and scrapers were abundant in all samples, but there were some differences in abundance between the test stations, control stations, and reference conditions (Figure 4 and Table 6). Percent gatherer-collectors, the most abundant FFG at the majority of sampling stations, was lower among test stations than the control stations and the BIOREF streams. The percentage of filterers was higher at all Piper Creek and Town Branch stations compared to reference conditions, especially at the test stations. Percent scraper values were much lower at the test stations than reference conditions. Scraper values at the control stations

Table 4
Fall 2015 and Spring 2016 Riffle/Pool Ozark/Osage EDU Stream Biological Criteria
Biological Support Categories, Biological Metric Values and Scores Shown in Parentheses
and Macroinvertebrate Stream Condition Index (MSCI) Scores for the Piper Creek and
Town Branch Sampling Stations.

Station	Sample No.	TR	EPTT	BI	SDI	MSCI	Support
Fall 2015							
Piper Creek #0.5	15133	65 (3)	12 (3)	6.9 (3)	3.25 (5)	14	P
Piper Creek #1	15134	76 (3)	12 (3)	6.6 (3)	3.21(3)	12	P
Piper Creek #1.5	15135	81 (3)	20 (5)	6.5 (5)	3.32 (5)	18	F
Town Branch #0.9	15136	53 (3)	5 (1)	6.7 (3)	3.00 (3)	10	P
Town Branch #1.1	15137	61 (3)	8 (1)	6.2 (5)	3.14 (3)	12	P
Metric Score=5	If	>84	>19	<6.6	>3.23	20-16	Full
Metric Score=3	If	84-42	19-9	6.6-8.3	3.23-1.61	14-10	Partial
Metric Score=1	If	<42	<9	>8.3	<1.61	8-4	Non
Spring 2016							
Piper Creek #0.5	16050	66 (3)	8 (1)	6.0 (5)	2.62 (3)	12	P
Piper Creek #1a	16051	75 (3)	7 (1)	6.6 (3)	2.98 (3)	10	P
Piper Creek #1b	16052	75 (3)	10 (1)	6.5 (3)	3.04 (3)	10	P
Piper Creek #1.5	16053	88 (3)	18 (3)	6.1 (3)	3.30 (5)	14	P
Town Branch #0.9	16054	52 (3)	3 (1)	6.9 (3)	1.87 (3)	10	P
Town Branch #1.1	16055	62 (3)	8 (1)	6.8 (3)	2.62 (3)	10	P
Metric Score=5	If	>90	>22	<6.1	>3.24	20-16	Full
Metric Score=3	If	90-45	22-11	6.1-8.1	3.24-1.62	14-10	Partial
Metric Score=1	If	<45	<11	>8.1	<1.62	8-4	Non

MSCI Scoring Table (in light gray) developed from Ozark/Osage EDU BIOREF samples ($n=28$ for fall sampling season and $n=40$ for spring sample season); TR=taxa richness; EPTT=Ephemeroptera, Plecoptera, Trichoptera Taxa; BI=Biotic Index; SDI=Shannon Diversity Index

Table 5
Fall 2015 and Spring 2016 Riffle/Pool Ozark/Osage EDU Candidate Reference Stream
Criteria, Biological Support Categories, Biological Metric Values and Scores Shown in
Parentheses, and Macroinvertebrate Stream Condition Index (MSCI) Scores for the Piper
Creek and Town Branch Sampling Stations

Station	Sample No.	TR	EPTT	BI	SDI	MSCI	Support
Fall 2015							
Piper Creek #0.5	15133	65 (3)	12 (3)	6.9 (3)	3.25 (5)	14	P
Piper Creek #1	15134	76 (3)	12 (3)	6.6 (3)	3.21(5)	14	P
Piper Creek #1.5	15135	81 (5)	20 (3)	6.5 (3)	3.32 (5)	16	F
Town Branch #0.9	15136	53 (3)	5 (1)	6.7 (3)	3.00 (3)	10	P
Town Branch #1.1	15137	61 (3)	8 (1)	6.2 (3)	3.14 (5)	12	P
Metric Score=5	If	>78	>20	<6.0	>3.06	20-16	Full
Metric Score=3	If	78-39	20-10	6.0-8.0	3.06-1.53	14-10	Partial
Metric Score=1	If	<39	<10	>8.0	<1.53	8-4	Non
Spring 2016							
Piper Creek #0.5	16050	66 (3)	8 (1)	6.0 (3)	2.62 (3)	10	P
Piper Creek #1a	16051	75 (3)	7 (1)	6.6 (3)	2.98 (3)	10	P
Piper Creek #1b	16052	75 (3)	10 (1)	6.5 (3)	3.04 (3)	10	P
Piper Creek #1.5	16053	88 (3)	18 (3)	6.1 (3)	3.30 (5)	14	P
Town Branch #0.9	16054	52 (3)	3 (1)	6.9 (3)	1.87 (3)	10	P
Town Branch #1.1	16055	62 (3)	8 (1)	6.8 (3)	2.62 (3)	10	P
Metric Score=5	If	>94	>24	<5.9	>3.27	20-16	Full
Metric Score=3	If	94-47	24-12	5.9-7.9	3.27-1.64	14-10	Partial
Metric Score=1	If	<47	<1	<7.9	<1.64	8-4	Non

MSCI Scoring Table (in light gray) developed from Ozark/Osage EDU BIOREF samples (n=6 for fall sampling season and n=7 for spring sampling season); TR=taxa richness; EPTT=Ephemeroptera, Plecoptera, Trichoptera Taxa; BI=Biotic Index; SDI=Shannon Diversity Index.

were slightly lower than the BIOREF streams. The scraper to filterer ratio was also lower at the test stations than reference conditions and the control stations. Percent predator values ranged from slightly lower to slightly higher than reference conditions. Piper Creek percent shredder values were similar to the BIOREF streams, but Town Branch values were much higher, especially at test station #0.9.

EPT Taxa Metrics

Compared to reference conditions, percent EPTT values ranged from much lower at Town Branch #0.9 to slightly higher at Piper Creek #1.5 (upstream control). With the exception of Piper Creek #1.5, percent Ephemeroptera was much lower at the Piper Creek and Town Branch stations compared to BIOREF streams. Percent Ephemeroptera was especially low at Town Branch #0.9. Plecoptera were found only at Piper Creek #1.5, the upstream control. Percent Trichoptera was much higher at all of the sampling stations compared to reference conditions.

Figure 3
Percent of Taxa by Biotic Index Range, Fall 2015

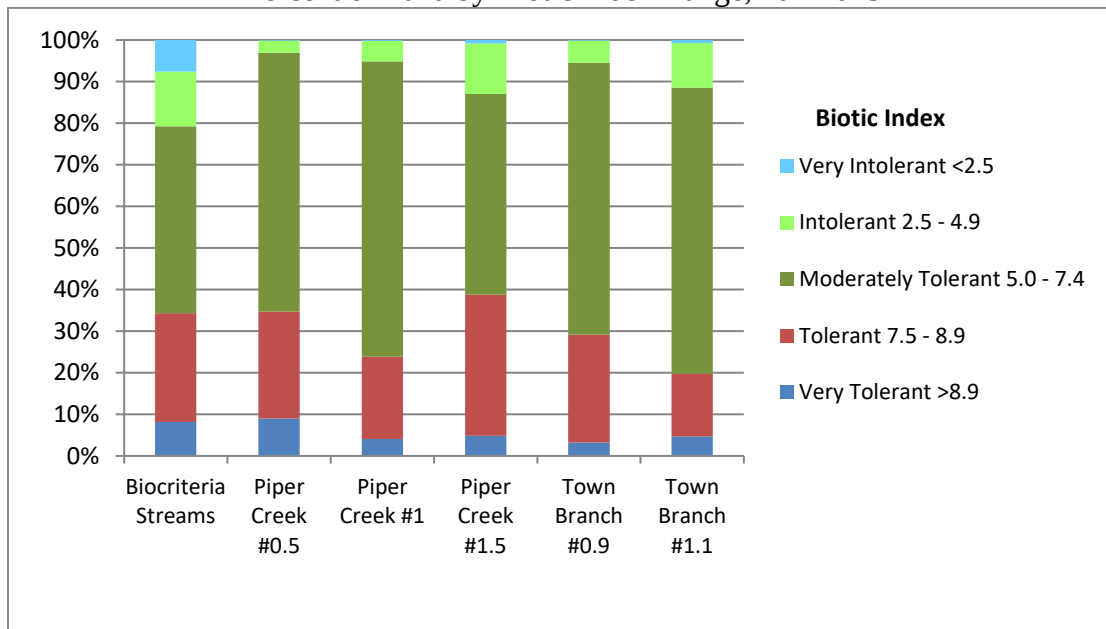


Figure 4
Percent of Taxa by Functional Feeding Group, Fall 2015

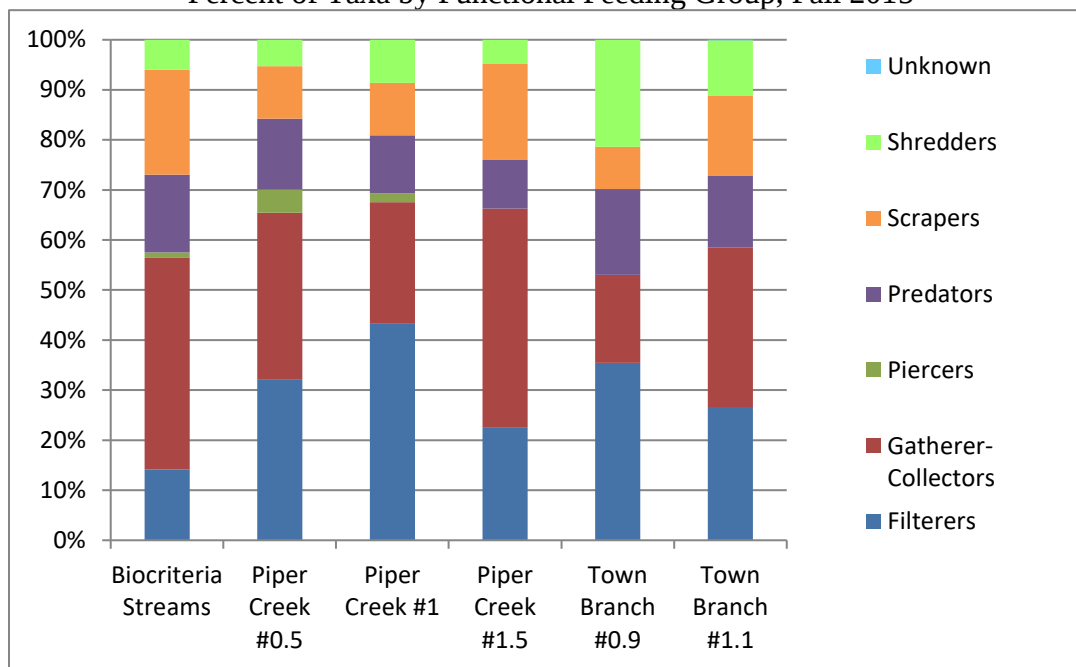


Table 6
Biological Metric Values for Sensitive Taxa, Functional Feeding Groups (FFG), and EPTT Metrics for Biological Criteria Reference Samples and Piper Creek and Town Branch Study Stations, Fall 2015

Variable-Station	Biocriteria Reference Data	Piper Creek #0.5 Test Station	Piper Creek #1 Test Station	Piper Creek #1.5 Control Station	Town Branch #0.9 Test Station	Town Branch #1.1 Control Station
Sample Number		15133	15134	15135	15136	15137
Sensitive Taxa						
% Biotic Index >8.9	8.2	9.0	4.0	4.8	3.2	4.7
% Biotic Index 7.5-8.9	26.1	25.7	19.8	34.0	26.0	15.0
% Biotic Index 5.0-7.4	44.9	62.2	71.0	48.2	65.4	68.9
% Biotic Index 2.5-4.9	13.1	2.9	4.9	12.1	5.3	10.8
% Biotic Index <2.5	7.6	0.2	0.2	0.8	0.2	0.7
Functional Feeding Groups						
% Filterers	14.2	32.2	43.4	22.6	34.5	26.6
% Gatherer-Collectors	42.3	33.3	24.2	43.7	17.1	31.9
% Parasites	0.03	--	--	--	0.2	--
% Piercers	1.1	4.7	1.8	--	2.6	0.1
% Predators	15.5	14.1	11.6	9.7	16.7	14.2
% Scrapers	21.0	10.5	10.5	19.2	8.2	16.0
% Shredders	6.0	5.3	8.6	4.8	20.8	11.1
% Unknown	0.01	--	--	--	--	0.1
Scraper/Filterer Ratio	1.5	0.3	0.2	0.8	0.2	0.6
EPT Metrics						
% EPTT	42.3	33.7	39.8	45.5	18.2	31.3
% Ephemeroptera	34.8	16.1	14.6	32.1	0.9	17.5
% Plecoptera	0.7	--	--	0.1	--	--
% Trichoptera	6.8	17.5	25.2	13.3	17.3	13.8

Biocriteria stream data values are average percent.

Macroinvertebrate Community Composition

Chironomidae was the dominant macroinvertebrate family in Piper Creek and Town Branch fall samples (Table 7). Percent Chironomidae ranged from slightly higher at Piper Creek 1.5 (upstream control) to much higher at Town Branch #0.9 compared to BIOREF streams. The chironomid *Tanytarsus* was common at all sampling stations, ranging from slightly higher than reference conditions at Piper Creek #1.5 to much higher at Town Branch #0.9. *Rheotanytarsus* was much higher at Piper Creek #1 and similar to or slightly higher at the other sampling stations compared to BIOREF streams. *Polypedilum flavum* was abundant at the two Town Branch stations and Piper Creek #1. At Town Branch #0.9, *P. flavum* and the tolerant chironomid *Dicrotendipes* were much higher in abundance than the other sampling stations and BIOREF streams.

Some non-chironomid taxa also were common in Piper Creek and Town Branch samples. The hydropsychid caddisfly *Cheumatopsyche* was abundant at all sampling stations, and the mayfly *Caenis latipennis* was abundant at the Piper Creek sampling stations. *Cheumatopsyche* was especially abundant at the three test stations and was much higher than BIOREF streams. The

percentage of *C. latipennis* in Piper Creek ranged from slightly lower at test station #0.5 to higher at test station #1.5 compared to BIOREF streams. *C. latipennis* was not collected in the two Town Branch samples. Other taxa that were common at some of the sampling stations were the amphipod *Hyaella azteca*, the riffle beetle *Stenelmis*, the mayfly *Baetis*, and the damselfly *Argia*. *H. azteca* was present in higher abundance at Piper Creek #1.5 (upstream control) than the other sampling stations and the BIOREF streams. *Stenelmis* was abundant at Piper Creek #0.5 and Town Branch #1.1 (upstream control). *Baetis* was abundant at most sampling stations, especially at Town Branch #1.1, compared to reference conditions. Except at Piper Creek #1.5, *Argia* was more abundant at the sampling stations than reference conditions.

Most dominant taxa found in BIOREF samples also were common in one or more of the Piper Creek and Town Branch samples. The only exception was the mayfly *Tricorythodes*. This mayfly was the most abundant taxon present in BIOREF samples, but it was found in low abundance in Piper Creek, and it was absent in Town Branch samples.

Most of the dominant taxa found in BIOREF streams and among study stations had BI values in the moderately tolerant range (BI = 5.0-7.4). Exceptions to this were *C. latipennis*, *Dicrotendipes*, and *Argia*, all of which have BI values in the tolerant range (BI=7.5-8.9). *Dicrotendipes* and *Argia* were much more abundant at the downstream test station on Town Branch (test station #0.9).

Table 7

Percent Dominant Macroinvertebrate Families and Taxa at Piper Creek and Town Branch Sampling Stations, and Ozark/Osage EDU
Biological Criteria Reference Samples, Fall 2015

Variable-Station	Biotic Index	Ozark/Osage Reference Streams	Piper Creek #0.5 Test Station	Piper Creek #1 Test Station	Piper Creek #1.5 Control Station	Town Branch #0.9 Test Station	Town Branch #1.1 Control Station
Sample Number			15133	15134	15135	15136	15137
Percent Dominant Families							
Chironomidae		21.1	28.8	37.8	24.2	55.5	36.6
Caenidae		11.3	5.5	7.4	12.3	--	--
Heptageniidae		9.9	0.8	2.5	12.5	--	0.9
Elmidae		7.9	8.5	4.5	5.6	2.1	12.6
Leptohyphidae		7.2	3.3	0.7	0.1	--	--
Hydropsychidae		3.7	17.4	24.0	6.6	16.0	8.4
Coenagrionidae		4.1	6.8	3.2	3.2	6.3	4.6
Baetidae		2.3	6.4	4.0	6.7	0.9	16.6
Hyaellidae		6.5	0.6	0.4	12.4	0.1	0.2
Planariidae		0.4	4.0	1.2	0.8	4.0	2.1
Ancylidae		1.1	0.6	2.6	0.4	2.7	1.0
Philopotamidae		1.0	L/R	0.2	5.4	--	5.3
Percent Dominant Taxa							
<i>Tricorythodes</i>	5.4	7.2	3.3	0.7	0.1	--	--
<i>Caenis latipennis</i>	7.6	6.8	5.5	7.4	12.3	--	--
<i>Hyaella azteca</i>	7.9	6.5	0.6	0.4	12.4	0.1	0.2
<i>Tanytarsus</i>	6.7	3.9	8.9	4.8	4.3	12.8	7.3
<i>Cheumatopsyche</i>	6.6	3.6	16.9	22.4	6.4	12.5	7.6
<i>Stenelmis</i>	5.4	3.4	6.4	3.5	3.6	2.1	12.2
<i>Baetis</i>	6.0	1.1	6.3	4.0	6.3	0.9	16.6
<i>Rheotanytarsus</i>	6.4	1.8	3.1	10.8	4.3	1.7	2.7
<i>Polypedilum flavum</i>	5.3	2.7	3.9	5.6	2.5	16.5	8.0
<i>Stenacron</i>	7.1	1.3	--	0.4	6.9	--	0.6
<i>Dicrotendipes</i>	7.9	0.9	2.0	2.0	0.4	7.0	1.8
<i>Argia</i>	8.7	1.6	4.1	2.5	1.1	6.3	4.6

Biocriteria reference stream data values are average percent.

Values in bold type represent the five dominant macroinvertebrate taxa for each station.

3.3.2.2 Spring 2016 Sampling Season

Percent Composition of Sensitive Taxa

Taxa found in Piper Creek and Town Branch spring samples were generally more tolerant of organic pollution than BIOREF streams (Figure 5 and Table 8). The only exception was the most downstream station on Piper Creek (test station #0.5), which had similar percentages of taxa with BI values above and below 5.0 compared to reference conditions. At the other sampling stations, percent taxa with BI values ≥ 5.0 was much higher and BI values < 5.0 were much lower than BIOREF streams. This observation was especially notable at Town Branch #0.9. Most of the taxa found in Piper Creek and Town Branch samples with BI values ≥ 5.0 had values in the moderately tolerant range (BI=5.0-7.4). Except at Piper Creek #0.5, the percentage of taxa found in the Piper Creek and Town Branch samples with BI values in the intolerant range (BI=2.5-4.9) and the very intolerant range (BI < 2.5) was much lower than reference conditions.

Percent Composition of Functional Feeding Groups (FFG)

Gatherer-collectors and shredders were generally the most abundant FFGs found in Piper Creek and Town Branch samples (Figure 6 and Table 8). Gatherer-collectors were the most abundant FFG at most of the sampling stations, ranging from much lower at Town Branch #0.9 to slightly higher at Piper Creek #0.5 compared to reference conditions. Except at the upstream control on Piper Creek (station #1.5), percent shredders were much higher in abundance at the sampling stations than BIOREF streams. Compared to reference conditions, percent filterers ranged from lower at Town Branch #0.9 to higher at all Piper Creek stations, except test station #0.5. Percent scraper values were much lower at the test stations than reference conditions. Scraper values at the control stations were higher at Piper Creek #1.5 and slightly lower at Town Branch #1.1 compared to BIOREF streams. The scraper to filterer ratio was also lower at the test stations than reference conditions and the control stations. Percent predator values were lower at most of the sampling stations compared to reference conditions, ranging from much lower at Town Branch #0.9 to a similar value at Piper Creek #1.5.

EPT Metrics

With the exception of Piper Creek #1.5 (upstream control) percent EPTT, percent Ephemeroptera, and percent Plecoptera values were much lower at the sampling stations compared to reference conditions (Table 8). At Piper Creek #1.5, EPTT and percent Ephemeroptera values were slightly lower and percent Plecoptera values were much lower than the biological criteria streams. Among the remaining sampling stations, percent Ephemeroptera was ≤ 1.0 percent, and Plecoptera were absent. Percent Trichoptera ranged from slightly lower at Town Branch #1.1 to slightly higher at Piper Creek #1b compared to reference conditions.

Macroinvertebrate Community Composition

Chironomids were abundant in all Piper Creek and Town Branch samples. With the exception of the upstream control Piper Creek (station #1.5), chironomids were much higher in abundance than reference conditions (Table 9). At Piper Creek #1.5, chironomid abundance was slightly higher than BIOREF streams. Chironomid taxa *Cricotopus/Orthocladius*, *Eukiefferiella*, *Tanytarsus*, and *Dicrotendipes* were abundant at most of the sampling stations. The chironomids

Figure 5
Percent of Taxa by Biotic Index Range, Spring 2016

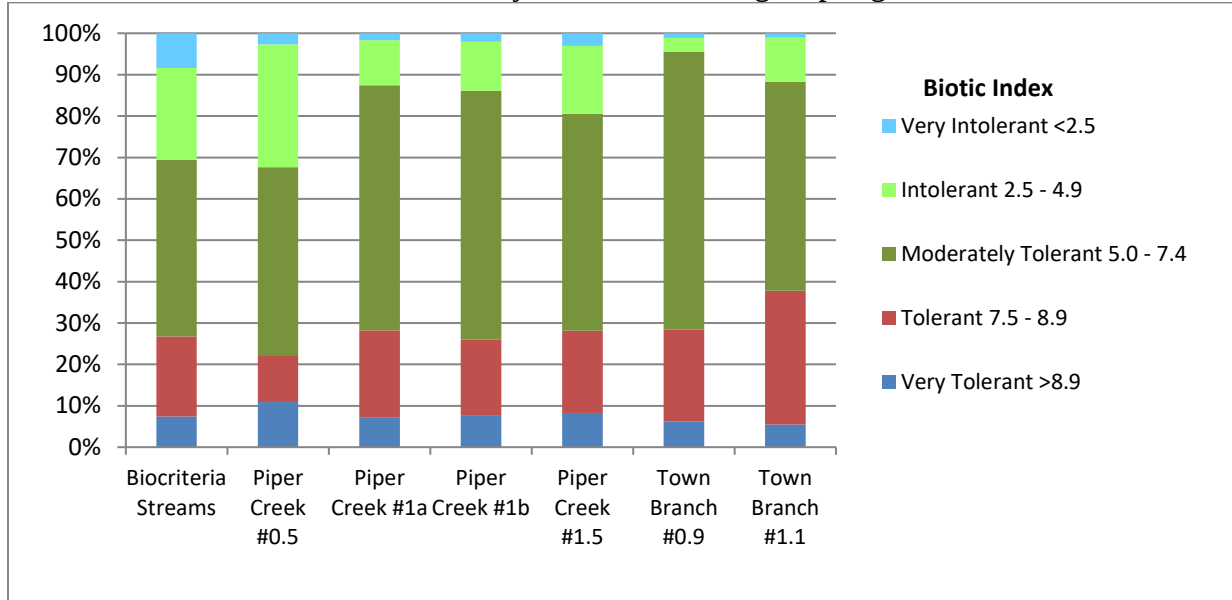


Figure 6
Percent of Taxa by Functional Feeding Group, Spring 2016

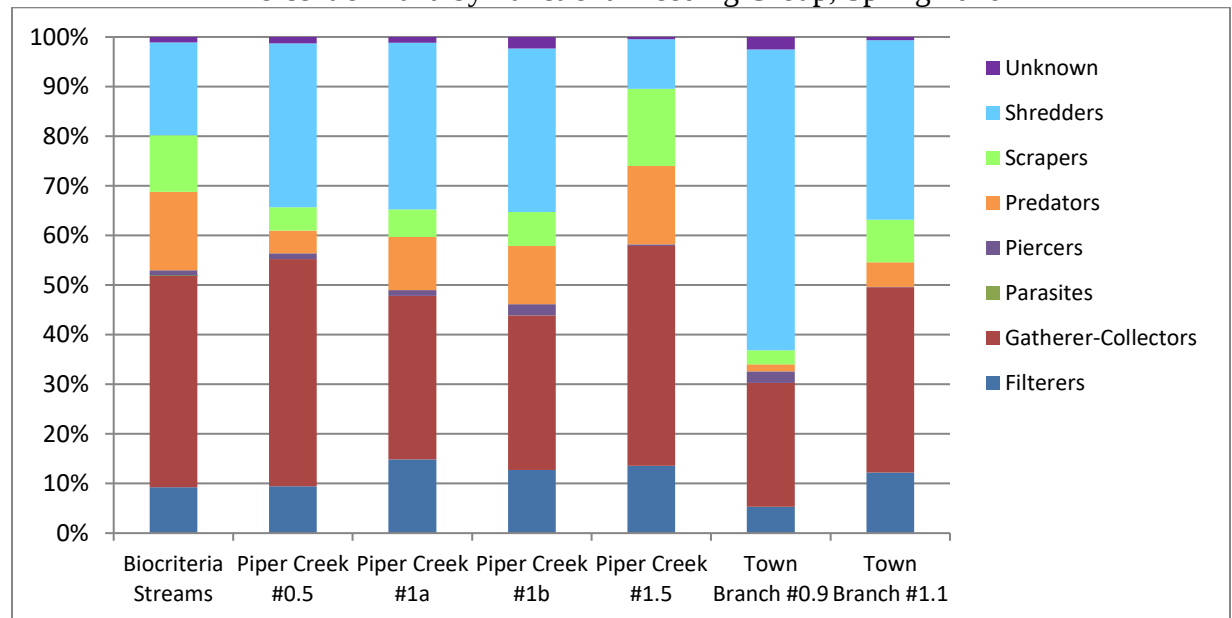


Table 8

Biological Metric Values for Sensitive Taxa, Functional Feeding Groups (FFG), and EPTT Metrics at Biological Criteria Reference Samples and Piper Creek and Town Branch Study Stations, Spring 2016

Variable-Station	Biocriteria Reference Data	Piper Creek #0.5 Test Station	Piper Creek #1a Test Station	Piper Creek #1b Test Station	Piper Creek #1.5 Control Station	Town Branch #0.9 Test Station	Town Branch #1.1 Control Station
Sample Number		16050	16051	16052	16053	16054	16055
Sensitive Taxa							
% Biotic Index >8.9	7.4	10.9	7.1	7.5	8.2	6.3	5.5
% Biotic Index 7.5-8.9	19.3	11.2	21.2	18.4	19.9	22.2	32.3
% Biotic Index 5.0-7.4	42.6	45.6	59.2	60.2	52.4	67.1	50.4
% Biotic Index 2.5-4.9	22.2	29.7	10.9	11.8	16.4	3.3	10.7
% Biotic Index <2.5	8.4	2.6	1.7	2.1	3.1	1.1	1.0
Functional Feeding Groups							
% Filterers	9.4	9.6	15.0	13.0	13.6	5.5	12.2
% Gatherer-Collectors	43.1	46.3	33.4	31.9	44.5	25.5	37.4
% Parasites	0.02	--	--	--	0.1	--	--
% Piercers	1.0	1.2	1.1	2.3	0.4	2.3	0.1
% Predators	15.9	4.6	10.8	12.0	15.8	1.5	5.0
% Scrapers	11.6	4.8	5.6	7.0	15.6	2.8	8.6
% Shredders	18.9	33.5	34.0	33.7	10.1	62.1	36.2
% Unknown	1.1	1.3	1.1	2.4	0.4	2.5	0.7
Scraper/Filterer Ratio	1.2	0.5	0.4	0.5	1.1	0.5	0.7
EPT Metrics							
% EPTT	29.3	2.0	3.1	5.2	20.4	3.9	1.6
% Ephemeroptera	19.4	0.4	1.0	1.0	16.3	--	0.4
% Plecoptera	7.2	--	--	--	1.6	--	--
% Trichoptera	2.6	1.6	2.1	4.3	2.4	3.9	1.2

Biocriteria stream data values are average percent.

Polypedilum illinoense group, *Thienemannimyia* group, and *Paratendipes* were abundant at some of the sampling stations. Except at Piper Creek #1.5, *Cricotopus/Orthocladius* was much more abundant than reference conditions. *Eukiefferiella* was more abundant at the Piper Creek sampling stations than reference conditions, especially at Piper Creek #0.5. At the Town Branch stations, *Eukiefferiella* was not very abundant at test station #0.9 and was slightly lower at control station #1.1 than BIOREF streams. *Tanytarsus* was abundant at all sampling stations and was more abundant than reference conditions at all but Town Branch #1.1. *Dicrotendipes* was more abundant at the sampling stations than BIOREF streams and was especially abundant at the Town Branch stations. *Polypedilum illinoense* group was found in low abundance at most of the sampling stations, but it was higher than reference conditions except at Town Branch #1.1. *Thienemannimyia* group and *Paratendipes* had higher values than BIOREF streams at the Piper Creek stations.

Certain non-chironomid taxa also were common in some Piper Creek and Town Branch samples. Although *C. latipennis* was very abundant at Piper Creek #1.5 (higher than reference conditions), it was found in very low numbers at the other sampling stations. *Stenelmis*, which was especially abundant at the two control stations, was more abundant than reference conditions at most of the sampling stations. The only stations that had lower values for *Stenelmis* were Piper Creek #0.5 and Town Branch #0.9. The caddisfly *Hydroptila* was more abundant at Piper Creek #1b and Town Branch #0.9 than BIOREF streams. Planariidae was not very abundant in any of the samples, but it made up about 2 percent of the Town Branch samples, which was higher than reference conditions.

Most of the dominant taxa in BIOREF samples were also common in one or more of the Piper Creek and Town Branch samples. The only exception was the amphipod *H. azteca*, which although abundant among BIOREF streams, either was absent or was found in low abundance in the Piper Creek and Town Branch samples.

Most of the dominant taxa found in BIOREF streams and at the study stations had BI values that were either in the moderately tolerant (BI = 5.0-7.4) or tolerant range (BI = 7.5-8.9). Exceptions to this trend was *Eukiefferiella*, which has a BI value in the intolerant range (BI = 2.5-4.9) and *Polypedilum illinoense* group, which has a BI value in the very tolerant range (BI > 8.9).

3.4 Physicochemical Water Data

Water samples and *in situ* field measurements were collected during the fall 2015 and spring 2016 macroinvertebrate sampling periods (Tables 10 and 11). Results showed that nutrient concentrations and turbidity were elevated compared to the U.S. EPA Nutrient Criteria recommended reference values for the Level III Ozark Highlands ecoregion (U.S. EPA 2000). Physicochemical results are arranged to demonstrate trends of certain variables that may suggest a source of effects at the Piper Creek and Town Branch sampling stations. Results shown here are for stream discharge, nitrate + nitrite-N, total nitrogen, total phosphorus, and turbidity by season.

Table 9

Percent Dominant Macroinvertebrate Families and Taxa at the Piper Creek and Town Branch Sampling Stations, and the Ozark/Osage
EDU Biological Criteria Reference Samples, Spring 2016

Variable-Station	Biotic Index	Ozark/Osage Reference Streams	Piper Creek #0.5 Test Station	Piper Creek #1a Test Station	Piper Creek #1b Test Station	Piper Creek #1.5 Control Station	Town Branch #0.9 Test Station	Town Branch #1.1 Control Station
Sample Number			16050	16051	16052	16053	16054	16055
Percent Dominant Families								
Chironomidae		47.3	89.3	87.0	83.2	53.9	87.3	79.7
Caenidae		7.6	0.1	0.8	0.9	12.3	--	0.1
Heptageniidae		4.4	0.2	0.2	0.1	3.4	--	0.1
Hyalellidae		4.3	--	--	--	0.6	--	L/R
Perlidae		3.3	--	--	--	1.6	--	--
Tubificidae		2.6	2.9	1.0	1.7	3.1	1.9	3.0
Elmidae		3.3	1.8	3.2	4.5	13.0	1.3	7.6
Hydroptilidae		0.8	0.8	0.8	2.2	0.3	2.2	0.1
Hydropsychidae		0.7	0.8	1.1	1.7	0.7	1.7	0.8
Coenagrionidae		0.7	--	1.7	1.8	2.2	0.2	1.7
Planariidae		0.4	0.7	0.2	0.5	0.4	1.8	1.9
Percent Dominant Taxa								
<i>Cricotopus/Orthocladus</i> grp.	6.5	13.9	24.9	24.4	24.4	4.1	56.8	27.7
<i>Eukiefferiella</i>	4.0	6.9	26.5	8.6	9.2	11.1	0.2	4.3
<i>Caenis latipennis</i>	7.6	5.1	0.1	0.8	0.9	12.3	--	0.1
<i>Hyalella azteca</i>	7.9	4.3	--	--	--	0.6	--	L/R
<i>Tanytarsus</i>	6.7	3.7	6.4	9.5	6.2	7.0	3.2	8.9
<i>Dicrotendipes</i>	7.9	2.0	7.4	9.5	7.3	0.8	16.2	21.0
<i>Polypedilum illinoense</i> grp.	9.2	0.9	3.9	2.0	1.9	2.7	1.4	0.5
<i>Thienemannimyia</i> grp.	6.0	1.6	2.0	6.0	6.0	6.5	0.7	1.4
<i>Stenelmis</i>	5.4	2.4	1.6	2.8	4.0	10.6	1.2	7.5
<i>Paratendipes</i>	5.3	0.5	2.0	4.2	4.7	8.1	0.1	0.8
<i>Hydroptila</i>	6.2	0.7	0.8	0.8	2.2	0.3	2.2	0.1
Planariidae	7.5	0.4	0.7	0.2	0.5	0.4	1.8	1.9

Biocriteria reference stream data values are average percent.

Values in bold type represent the five dominant macroinvertebrate taxa for each station.

L/R indicates that taxa group was only found in the large/rare part of sample.

3.4.1 Stream Discharge

Discharge at the Piper Creek sampling stations during the fall 2015 sampling season ranged from 2.5 cfs at Piper Creek #1.5 (upstream control) to 6.1 cfs at Piper Creek #0.5 (Table 10). At Town Branch, discharge was 1.7 cfs at the upstream control (station #1.1) and 3.7 cfs at test station #0.9

Discharge was higher during the spring 2016 sampling season (Table 11). Piper Creek discharge ranged from 5.6 cfs at Piper Creek #1.5 to 12.0 cfs at Piper Creek #0.5. At Town Branch, discharge was 2.4 cfs at Town Branch #1.1 and 4.5 cfs at Town Branch #0.9.

3.4.2 Nitrate + Nitrite-N

During the fall 2015 sampling season, all of the Piper Creek and Town Branch samples had nitrate + nitrite-N concentrations above the U.S. EPA recommended reference value (0.24 mg/L) for the Level III Ozark Highlands ecoregion (U.S. EPA 2000). Nitrate + nitrite-N ranged from 0.31 mg/L at Piper Creek #1.5 to 8.55 mg/L at Town Branch #0.9 (Table 10).

Nitrate + nitrite-N concentrations were also higher than the U.S. EPA recommended reference value during the spring 2016 sampling season at all of the sampling stations except Piper Creek #1.5 (Table 11). Nitrate + nitrite-N ranged from 0.03 mg/L at Piper Creek #1.5 to 4.95 mg/L at Town Branch #0.9.

3.4.3 Total Nitrogen

In fall 2015, all of the sampling stations had total nitrogen concentrations above the U.S. EPA recommended reference value (0.29 mg/L) for the Level III Ozark Highlands ecoregion (U.S. EPA 2000). Total nitrogen ranged from 0.64 mg/L at Piper Creek #1.5 to 9.16 mg/L at Town Branch #0.9 (Table 10).

Total nitrogen concentrations were also higher than the U.S. EPA recommended reference value during the spring 2016 sampling season (Table 11). Total nitrogen ranged from 0.34 mg/L at Piper Creek #1.5 to 5.41 mg/L at Town Branch #0.9.

3.4.4 Total Phosphorus

During the fall 2015 sampling season, total phosphorous was elevated at all sampling stations compared to the U.S. EPA recommended reference value (0.007 mg/L) for the Level III Ozark Highlands ecoregion (U.S. EPA 2000). Total phosphorus ranged from 0.05 mg/L at Town Branch #1.1 to 1.56 mg/L at Town Branch #0.9 (Table 10).

Total phosphorus concentrations were also higher than the U.S. EPA recommended reference value during the spring 2016 sampling season (Table 11). Total phosphorus ranged from 0.02 mg/L at Piper Creek #1.5 to 0.92 mg/l at Town Branch #0.9.

3.4.5 Turbidity

Turbidity concentrations were higher at most of the sampling stations compared to the U.S. EPA recommended reference value of 1.43 NTU for turbidity (U.S. EPA 2000) during the fall 2015

sampling season. Turbidity ranged from 1.20 NTU at Piper Creek #0.5 to 2.40 at Piper Creek #1 (Table 10).

Turbidity was elevated compared to the U.S. EPA recommended reference value at all of the sampling stations during the spring 2016 sampling season. Turbidity ranged from 1.7 NTU at Piper Creek #0.5, Piper Creek #1b, and Town Branch #1.1 to 2.60 NTU at Piper Creek #1a and Town Branch #0.9 (Table 11).

Table 10
Physicochemical Variables for Surface Water Samples at the Piper Creek and Town Branch
Bioassessment Study Sampling Stations, Fall 2015

	Piper Creek #0.5	Piper Creek #1	Piper Creek #1.5	Town Branch #0.9	Town Branch #1.1
Invertebrate Sample Number	15133	15134	15135	15136	15137
Physicochemical Sample Number	153638	153639	153640	153641	153642
Sample Date	09/21/2015	09/21/2015	09/21/2015	09/21/2015	09/22/2015
Sample Time	1022	1215	1410	1610	0855
Ammonia	<0.05 ^a	<0.04 ^a	0.05	0.05	0.04 ^a
Chloride	33.9	30.7	13.9	52.0	24.3
Sulfate	14.4	15.0	10.2	19.9	15.2
Total Recoverable Calcium	52.3 ^b	53.9 ^b	44.8 ^b	57.1 ^b	62.9
Total Recoverable Magnesium	25.7 ^b	25.6 ^b	23.4 ^b	26.4 ^b	28.7
Hardness as CaCO ₃	236	240	208	251	275
Dissolved Oxygen	11.01	9.82	9.32	9.67	7.71
Discharge (cfs)	6.13	5.71	2.52	3.69	1.73
pH (Units)	8.6	8.4	8.2	8.5	8.2
Conductivity (µmhos/cm)	528	528	412	645	567
Temperature (°C)	18.2	18.9	20.5	21.6	18.0
Turbidity (NTU)	1.2	2.4	1.8	1.6	1.4
Total Suspended Solids	<5 ^c	<5 ^c	18.0	<5 ^a	<5 ^a
Nitrate + Nitrite	3.30^b	3.44^b	0.31	8.55^b	2.00
Total Nitrogen	3.49	3.71	0.64	9.16	2.14
Total Phosphorus	0.60	0.56	0.06	1.56	0.05^a

^aEstimated value, detected below Practical Quantitation Limit

^bSample was diluted during analysis

^cBelow detectable limits

Units mg/L unless otherwise noted. Values in bold exceed Missouri Water Quality Standards or are elevated compared to U.S. EPA recommended reference condition values.

Table 11
Physicochemical Variables for Surface Water Samples at the Piper Creek and Town Branch
Bioassessment Study Sampling Stations, Spring 2016

	Piper Creek #0.5 Test Station	Piper Creek #1a Test Station	Piper Creek #1b Test Station	Piper Creek #1.5 Control Station	Town Branch #0.9 Test Station	Town Branch #1.1 Control Station
Invertebrate Sample Number	16050	16051	16052	16053	16054	16055
Physicochemical Sample Number	161895	161896	161897	161898	161899	161900
Sample Date	03/15/2016	03/15/2016	03/15/2016	03/15/2016	03/15/2016	03/15/2016
Sample Time	1100	1300	1302	1455	1600	1700
Ammonia	<0.03 ^a	<0.03 ^a	<0.03 ^a	<0.03 ^a	<0.03 ^a	<0.03 ^a
Chloride	29.0	31.4	30.9	18.2	42.3	26.9
Sulfate	16.9	15.9 ^c	15.8	14.4	15.9	14.0
Total Recoverable Calcium	48.4	47.6	48.2	43.7	48.4	43.0
Total Recoverable Magnesium	24.8	23.6	24.1	23.6	24.1	24.4
Hardness as CaCO ₃	223	216	220	206	220	208
Dissolved Oxygen	15.91	16.04	16.21	14.69	14.91	14.62
Discharge (cfs)	12.02	10.63	10.94	5.59	4.68	2.41
pH (Units)	9.1	8.9	9.0	8.6	9.0	8.9
Conductivity (µmhos/cm)	475	450	480	414	522	427
Temperature (°C)	15.3	16.7	17.1	18.2	18.4	19.0
Turbidity (NTU)	1.7	2.6	1.7	2.2	2.6	1.7
Total Suspended Solids	<5 ^{ab}	<5 ^{ab}	<5 ^{ab}	<5 ^{ab}	<5 ^{ab}	<5 ^{ab}
Nitrate + Nitrite	2.00	2.63^d	2.62^d	0.03	4.95^d	1.27
Total Nitrogen	2.45	2.98	3.11	0.34	5.41	1.47
Total Phosphorus	0.42	0.50	0.51	0.02^e	0.92	0.01^e

^aBelow detectable limits

^bEstimated value, QC data outside limits

^cEstimated value, matrix interference

^dSample was diluted during analysis

^eEstimated value, detected below Practical Quantitation Limit

Units mg/L unless otherwise noted. Values in bold exceed Missouri Water Quality Standards or are elevated compared to U.S. EPA recommended reference condition values.

3.5 Quality Assurance/Quality Control (QA/QC)

3.5.1 Duplicate Samples

Quantitative Similarity Index for Taxa (QSIT) is a sampling protocol quality control measure that expresses taxa similarity between two samples as a percentage. QSIT was calculated for the duplicate samples collected at Piper Creek #1 during the spring 2016 sampling season. Duplicate samples are expected to have a score of 70 percent or greater (Rabeni et al. 1999). The spring 2016 QSIT for duplicate samples collected at Piper Creek #1 was 88.4 percent.

Duplicate water samples were also collected at Piper Creek #1 during the spring 2016 sampling season (Table 11). Field measurements and water sample physicochemical analysis results for the duplicate samples were similar except for conductivity and turbidity. Conductivity was 30 µmhos/cm higher in sample number 161897 (Piper Creek #1b) and turbidity was 0.9 NTU higher for sample number 161896 (Piper Creek #1a). Neither of these differences, however, exceeded

the duplicate sample difference criteria specified in the Fiscal Year 2016 Quality Assurance Project Plan (MoDNR 2015a).

4.0 Data Trends

4.1 Macroinvertebrate Biological Assessment

4.1.1 MSCI and Biological Metrics

A comparison between the 2003-2004 study and the current study (2015-2016) showed that MSCI scores were similar at most of the sampling stations even though three of the stations were moved to slightly different locations in 2015-2016 (Tables 12 and 13). The only exception was Piper Creek #1.5 (upstream control), which had a fully supporting MSCI of 18 in the fall 2015 sampling season and a partially supporting MSCI score of 14 in spring 2016. In comparison, Piper Creek #2 had a partially supporting MSCI score of 10 during both sampling seasons in the 2003-2004 study. The Piper Creek upstream control station was moved in 2015-2016 (Piper Creek #1.5) because the sampling reach in 2003-2004 (Piper Creek #2) was located in a cattle pasture, which affected habitat quality. At Piper Creek #1.5, three of the biological metrics (EPT, BI, and SDI) performed better during both 2015-2016 sampling seasons compared to Piper Creek #2 in 2003-2004. These improved biological metrics were sufficient to result in higher MSCI scores.

During the 2003-2004 sample seasons, Piper Creek #1 attained a slightly higher partially supporting MSCI score in the fall 2003 sample and the same partially supporting MSCI score in the spring 2004 sample compared to samples collected in 2015-2016. Town Branch #2 also had a slightly higher partially supporting score compared to Town Branch #1.1, but only during the fall sampling season. The fall 2003 Piper Creek #1 MSCI score was 14 compared to 12 in 2015, and the spring 2004 MSCI score was 12, compared to a score of 10 for duplicate samples collected in 2016. The fall 2003 Town Branch #2 (upstream control) MSCI score was 14 compared to 12 at Town Branch #1.1 in 2015. A lower BI during both sampling seasons at Piper Creek #1 and a slightly higher EPTT at Town Branch #2 during the fall sampling season led to the slightly higher MSCI scores in 2003-2004.

4.1.2 Macroinvertebrate Community Composition

During the fall sampling season, percent EPTT and percent Trichoptera were much higher in 2015 than in 2003 (Table 14). Percent Ephemeroptera was much higher in fall 2015 at the upstream control stations on Piper Creek (station #1.5) and Town Branch (station #1.1) than the control stations (Piper Creek #2 and Town Branch #2) sampled in 2003. At the other sampling stations, percent Ephemeroptera was similar between sample years.

Most of the dominant taxa that were found in samples during the fall sampling season were common in 2003 and 2015, but there were large differences in abundance of some taxa between sample years (Table 14). The caddisfly *Cheumatopsyche*, the mayfly *Baetis*, and the mayfly *C. latipennis* were generally much more abundant in 2015 than 2003. In 2003, the riffle beetle *Stenelmis*, the chironomid *P. flavum*, and tubificid worms were more abundant than in 2015 at most sampling stations.

During the spring sampling season, percent EPTT was similar at most stations between sample years, but percent Trichoptera was higher at all sites in 2016 (Table 15). The only stations that had different percent EPTT values between sample years were Piper Creek #1.5 and Town Branch #0.9 in 2016, which had higher values than Piper Creek #2 and Town Branch #1 2004 samples. Percent Ephemeroptera was much higher at the Piper Creek upstream control in 2016 (Station #1.5) than in 2004 (Station #2). Percent Ephemeroptera was only slightly higher at the remaining sampling stations in 2004.

Like the fall sampling season, most of the dominant taxa present in spring samples were common during both sample years, but there were some differences in abundance of certain taxa (Table 15). Chironomids were the dominant taxa at most stations during both sample years, although their relative percentages varied. The only exceptions were at Piper Creek #1 in 2004 and the Piper Creek upstream control stations (Stations #1.5 and #2) for both sampling years. Chironomids *Eukiefferiella* and *Cricotopus/Orthocladius* group were abundant during both sample years. *Eukiefferiella* was more abundant at the Piper Creek test stations and the upstream control station on Town Branch (station #1.1) in 2016. *Cricotopus/Orthocladius* group had similar abundance values at most of the sampling stations between sample years and were especially abundant in the Town Branch samples. Two other chironomids, *Dicrotendipes* and *Tanytarsus*, were generally much more abundant among stations in 2016 than 2004. The only exception was *Dicrotendipes*, which was only slightly more numerous at Piper Creek #1.5 in 2016 than Piper Creek #2 in 2004. *Stenelmis* and *P. flavum* were generally more abundant in 2004 than 2016.

4.2 Physicochemical Data

A comparison of water quality data from the 2003-2004 study and the current study showed elevated nutrient concentrations and turbidity values during both sampling periods compared to U.S. EPA Nutrient Criteria recommended reference values for the Level III Ozark Highlands ecoregion (Tables 16 and 17). The main difference in the nutrient data between the sampling periods was that nitrate + nitrite-N and total phosphorus concentrations were much higher at the Piper Creek and Town Branch test stations during the fall 2003 sampling season and nitrate + nitrite-N was higher at the Town Branch test station (station #1) during the spring 2004 sampling season compared to 2015-2016 results. Turbidity was also higher among stations during the fall sampling season in 2003. Turbidity results from the spring sampling season were more variable between sample periods.

Table 12
Riffle/Pool Ozark/Osage EDU Perennial/Wadeable Biological Criteria, Biological Support
Categories, and Macroinvertebrate Stream Condition Index (MSCI) Scores at the Piper
Creek and Town Branch Sampling Stations, Fall Sampling Season

Station	Sample Year	Sample No.	TR	EPTT	BI	SDI	MSCI	Support
Fall Sampling Season								
Piper Creek #0.5	2015	15133	65 (3)	12 (3)	6.9 (3)	3.25 (5)	14	P
Piper Creek #1	2003	0318710	62 (3)	9 (3)	6.4 (5)	3.13 (5)	14	P
	2015	15134	76 (3)	12 (3)	6.6 (3)	3.21(3)	12	P
Piper Creek #1.5	2015	15135	81 (3)	20 (5)	6.5 (5)	3.32 (5)	18	F
Piper Creek #2	2003	0318711	65 (3)	3 (1)	6.9 (3)	2.97 (3)	10	P
Town Branch #0.9	2015	15136	53 (3)	5 (1)	6.7 (3)	3.00 (3)	10	P
Town Branch #1	2003	0318712	57 (3)	7 (1)	6.8 (3)	2.86 (3)	10	P
Town Branch #1.1	2015	15137	61 (3)	8 (1)	6.2 (5)	3.14 (3)	12	P
Town Branch #2	2003	0318713	75 (3)	9 (3)	6.4 (5)	3.00 (3)	14	P
Metric Score=5		If	>84	>19	<6.6	>3.23	20-16	Full
Metric Score=3		If	84-42	19-9	6.6-8.3	3.23-1.61	14-10	Partial
Metric Score=1		If	<42	<9	>8.3	<1.61	8-4	Non

MSCI Scoring Table (in light gray) developed from Ozark/Osage EDU BIOREF samples (n=28); TR=taxa richness;
EPTT=Ephemeroptera, Plecoptera, Trichoptera Taxa; BI=Biotic Index; SDI=Shannon Diversity Index

Table 13
Riffle/Pool Ozark/Osage EDU Perennial/Wadeable Biological Criteria, Biological Support
Categories, and Macroinvertebrate Stream Condition Index (MSCI) Scores at Piper Creek
and Town Branch Sampling Stations, Spring Sampling Season

Station	Sample Year	Sample No.	TR	EPTT	BI	SDI	MSCI	Support
Spring Sampling Season								
Piper Creek #0.5	2016	16050	66 (3)	8 (1)	6.0 (5)	2.62 (3)	12	P
Piper Creek #1	2004	0418698	75 (3)	10 (1)	6.1 (3)	2.96 (3)	10	P
	2016	16051	75 (3)	7 (1)	6.6 (3)	2.98 (3)	10	P
	2016	16052	75 (3)	10 (1)	6.5 (3)	3.04 (3)	10	P
Piper Creek #1.5	2016	16053	88 (3)	18 (3)	6.1 (3)	3.30 (5)	14	P
Piper Creek #2	2004	0418699	83 (3)	9 (1)	6.2 (3)	2.98 (3)	10	P
Town Branch #0.9	2016	16054	52 (3)	3 (1)	6.9 (3)	1.87 (3)	10	P
Town Branch #1	2004	0418700	51 (3)	4 (1)	6.9 (3)	2.06 (3)	10	P
Town Branch #1.1	2016	16055	62 (3)	8 (1)	6.8 (3)	2.62 (3)	10	P
Town Branch #2	2004	0418701	52 (3)	5 (1)	6.2 (3)	1.62 (3)	10	P
Metric Score=5		If	>90	>22	<6.1	>3.24	20-16	Full
Metric Score=3		If	90-45	22-11	6.1-8.1	3.24-1.62	14-10	Partial
Metric Score=1		If	<45	<11	>8.1	<1.62	8-4	Non

MSCI Scoring Table (in light gray) developed from Ozark/Osage EDU BIOREF samples ($n=40$); TR=taxa richness;
EPTT=Ephemeroptera, Plecoptera, Trichoptera Taxa; BI=Biotic Index; SDI=Shannon Diversity Index

Table 14
Percent EPT, Dominant Macroinvertebrate Families and Macroinvertebrate Taxa at the Piper Creek and Town Branch Stations, Fall 2003 and 2015

Variable-Station	Biotic Index	Piper Creek #0.5	Piper Creek #1		Piper Creek #1.5	Piper Creek #2	Town Branch #0.9	Town Branch #1	Town Branch #1.1	Town Branch #2
Sample Number		15133	0318710	15134	15135	0318711	15136	0318713	15137	0318713
Sample Year		2015	2003	2015	2015	2003	2015	2003	2015	2003
EPT Metrics										
% EPTT		33.7	19.7	39.8	45.5	1.9	18.2	5.6	31.3	7.8
% Ephemeroptera		16.1	17.6	14.6	32.1	1.8	0.9	2.0	17.5	6.9
% Plecoptera		--	--	--	0.1	--	--	--	--	--
% Trichoptera		17.5	2.1	25.2	13.3	0.1	17.3	3.6	13.8	0.9
Percent Dominant Families										
Chironomidae		28.8	27.4	37.8	24.2	22.6	55.5	49.7	36.6	47.0
Hydropsychidae		17.4	2.1	24.0	6.6	0.1	16.0	3.5	8.4	0.3
Elmidae		8.5	19.0	4.5	5.6	18.6	2.1	20.3	12.6	15.6
Coenagrionidae		6.8	5.0	3.2	3.2	4.6	6.3	1.4	4.6	1.2
Baetidae		6.4	10.2	4.0	6.7	0.2	0.9	0.9	16.6	15.6
Tubificidae		4.7	6.4	1.8	2.2	13.0	1.1	7.0	2.5	3.2
Heptageniidae		0.8	6.1	2.5	12.5	--	--	1.0	0.9	3.5
Caenidae		5.5	1.3	7.4	12.3	1.7	--	0.1	--	5.7
Hyalellidae		0.6	4.9	0.4	12.4	11.4	0.1	0.1	0.2	--
Corixidae		--	--	--	--	6.5	--	--	--	----
Planariidae		4.0	5.1	1.2	0.8	6.0	4.0	8.6	2.1	0.1
Ancylidae		0.6	4.7	2.6	0.4	0.5	2.7	0.6	1.0	10.2
Percent Dominant Taxa										
Cheumatopsyche	6.6	16.9	2.1	22.4	6.4	0.1	12.5	3.3	7.6	0.2
Tanytarsus	6.7	8.9	1.6	4.8	4.3	2.7	12.8	10.0	7.3	10.9
Stenelmis	5.4	6.4	17.3	3.5	3.6	17.0	2.1	16.3	12.2	23.4
Baetis	6.0	6.3	10.1	4.0	6.3	--	1.7	0.9	16.6	2.2
Caenis latipennis	7.6	5.5	1.3	7.4	12.3	1.7	--	0.1	--	0.6
Polypedilum flavum	5.3	3.9	10.8	5.6	2.5	9.4	16.5	16.3	8.0	15.0
Tubificidae	9.2	4.0	6.0	1.6	2.1	12.2	1.0	7.0	2.5	1.8
Planariidae	7.5	4.0	5.1	1.2	0.8	6.0	4.0	8.6	2.1	4.3
Rheotanytarsus	6.4	3.1	1.6	10.8	4.3	0.1	1.7	2.4	2.7	0.6
Hyalella azteca	7.9	0.6	4.9	0.4	12.4	11.4	0.1	0.1	0.2	--
Stenacron	7.1	--	1.6	0.4	6.9	--	--	0.3	0.6	1.6
Corixidae	6.0	--	--	--	--	6.5	--	--	--	--
Dicrotendipes	7.9	2.0	0.1	2.0	0.4	0.8	7.0	0.8	1.8	0.2
Argia	8.7	4.1	4.3	2.5	1.1	1.2	6.3	1.2	4.6	5.0

Table 15

Percent EPT, Dominant Macroinvertebrate Families and Macroinvertebrate Taxa at the Piper Creek and Town Branch Stations, Spring 2004 and 2016

Variable-Station	Biotic Index	Piper Creek #0.5	Piper Creek #1			Piper Creek #1.5	Piper Creek #2	Town Branch #0.9	Town Branch #1	Town Branch #1.1	Town Branch #2
Sample Number		16050	0418698	16051	16052	16053	0418699	16054	0418700	16055	0418701
Sample Year		2016	2004	2016	2016	2016	2004	2016	2004	2016	2004
EPT Metrics											
% EPTT		2.0	4.6	3.1	5.2	20.4	8.2	3.9	0.9	1.6	2.0
% Ephemeroptera		0.4	2.9	1.0	1.0	16.3	6.1	--	0.6	0.4	1.7
% Plecoptera		--	1.0	--	--	1.6	2.0	--	--	--	--
% Trichoptera		1.6	0.7	2.1	4.3	2.4	0.1	3.9	0.3	1.2	0.3
Percent Dominant Families											
Chironomidae		89.3	48.8	87.0	83.2	53.9	51.9	87.3	73.1	79.7	84.3
Tubificidae		2.9	3.0	1.0	1.7	3.1	6.1	1.9	4.3	3.0	0.9
Elmidae		1.8	24.3	3.2	4.5	13.0	14.2	1.3	7.3	7.6	7.6
Hydroptilidae		0.8	0.2	0.8	2.2	0.3	--	2.2	0.3	0.1	0.2
Hydropsychidae		0.8	0.6	1.1	1.7	0.7	0.1	1.7	0.1	0.8	0.1
Planariidae		0.7	5.5	0.2	0.5	0.4	1.1	1.8	7.8	1.9	0.4
Pleuroceridae		0.3	4.0	--	0.3	0.4	0.3	--	--	--	--
Coenagrionidae		--	0.9	1.7	1.8	2.2	4.9	0.2	0.8	1.7	0.4
Caenidae		0.1	1.3	0.8	0.9	12.3	5.1	--	0.3	0.1	0.7
Heptageniidae		0.2	1.6	0.2	0.1	3.4	0.4	--	0.3	0.1	1.0
Arachnoidea		0.3	1.2	0.2	--	1.5	0.2	--	2.0	0.1	0.4
Crangonyctidae		L/R	0.5	--	0.1	--	0.4	--	0.2	0.7	2.4
Percent Dominant Taxa											
<i>Eukiefferiella</i>	4.0	26.5	4.8	8.6	9.2	11.1	22.5	0.2	--	4.3	0.2
<i>Cricotopus/Orthocladius</i> grp.	6.5	24.9	20.0	24.4	24.4	4.1	9.6	56.8	50.8	27.7	65.7
<i>Dicrotendipes</i>	7.9	7.4	1.8	9.5	7.3	0.8	0.3	16.2	9.6	21.0	6.0
<i>Tanytarsus</i>	6.7	6.4	3.2	9.5	6.2	7.0	3.9	3.2	1.2	8.9	2.0
<i>Polypedilum illinoense</i> grp.	9.2	3.9	0.8	2.0	1.9	2.7	--	1.4	2.7	0.5	0.7
<i>Stenelmis</i>	5.4	1.6	24.1	2.8	4.0	10.6	13.8	1.2	6.9	7.5	7.5
Planariidae	7.5	0.7	5.5	0.2	0.5	0.4	1.1	1.8	7.8	1.9	0.4
<i>Polypedilum flavum</i>	5.3	1.9	5.2	1.2	0.6	--	4.8	0.7	2.7	0.1	1.7
<i>Thienemannimyia</i> grp.	6.0	2.0	0.5	6.0	6.0	6.5	0.1	0.7	0.3	1.4	0.4
<i>Caenis latipennis</i>	7.6	0.1	1.3	0.8	0.9	12.3	5.1	--	0.3	0.1	--
<i>Paratendipes</i>	5.3	2.0	1.7	4.2	4.7	8.1	1.7	0.1	0.1	0.8	0.1
<i>Hydrobaenus</i>	9.6	2.4	2.1	1.8	1.6	0.1	0.7	0.4	0.3	0.4	2.7
<i>Crangonyx</i>	8.0	L/R	0.5	--	0.1	--	0.4	--	0.2	0.7	2.4

L/R indicates that taxa group was only found in the large/rare part of the sample.

Table 16
Physicochemical Variables from Water Samples collected at the Piper Creek and Town Branch Bioassessment Study Sampling Stations, Fall 2003 and 2015

	Piper Creek #0.5	Piper Creek #1		Piper Creek #1.5	Piper Creek #2	Town Branch #0.9	Town Branch #1	Town Branch #1.1	Town Branch #2
Sample Number	153638	0300823	153639	153640	0300824	153641	0300825	153642	0300826
Sample Date	09/21/2015	09/24/2003	09/21/2015	09/21/2015	09/24/2003	09/21/2015	09/24/2003	09/22/2015	09/24/2003
Sample Time	1022	1520	1215	1410	1400	1610	1135	0855	0935
Ammonia	<0.05 ^a	<0.03 ^c	<0.04 ^a	0.05	<0.03 ^c	0.05	0.03 ^c	0.04 ^a	0.03 ^c
Chloride	33.9	65.5	30.7	13.9	19.4	52.0	78.8	24.3	24.5
Sulfate	14.4	--	15.0	10.2	--	19.9	--	15.2	--
Total Recoverable Calcium	52.3 ^b	--	53.9 ^b	44.8 ^b	--	57.1 ^b	--	62.9	--
Total Recoverable Magnesium	25.7 ^b	--	25.6 ^b	23.4 ^b	--	26.4 ^b	--	28.7	--
Hardness as CaCO ₃	236	--	240	208	--	251	--	275	--
Dissolved Oxygen	11.01	9.80	9.82	9.32	6.25	9.67	8.30	7.71	9.45
Discharge (cfs)	6.13	2.55	5.71	2.52	0.11	3.69	3.09	1.73	0.45
pH (Units)	8.6	8.3	8.4	8.2	7.9	8.5	7.8	8.2	8.1
Conductivity (µmhos/cm)	528	675	528	412	395	645	756	567	534
Temperature (°C)	18.2	21.0	18.9	20.5	23.0	21.6	21.0	18.0	18.0
Turbidity (NTU)	1.2	7.9	2.4	1.8	14.0	1.6	4.45	1.4	10.6
Total Suspended Solids	<5 ^c	--	<5 ^c	18.0	--	<5 ^a	--	<5 ^a	--
Nitrate + Nitrite-N	3.30^b	9.86	3.44^b	0.31	0.10	8.55^b	13.40	2.00	2.04
TKN		0.06 ^{abd}	--	--	1.02	--	0.55	--	0.05 ^c
Total Nitrogen	3.49	--	3.71	0.64	--	9.16	--	2.14	--
Total Phosphorus	0.60	1.94	0.56	0.06	0.13	1.56	2.69	0.05^a	0.03 ^a

^aEstimated value, detected below Practical Quantitation Limits

^bSample diluted during analysis

^cBelow detectable limits

^dEstimated value, matrix interference

Units mg/L unless otherwise noted. Values in bold are elevated compared to water quality standards or U.S. EPA recommended reference condition values.

Table 17
Physicochemical Variables from Water Samples collected at the Piper Creek and Town Branch Bioassessment Study Sampling Stations, Spring 2004 and 2016

	Piper Creek #0.5	Piper Creek #1			Piper Creek #1.5	Piper Creek #2	Town Branch #0.9	Town Branch #1	Town Branch #1.1	Town Branch #2
Sample Number	161895	0411050	161896	161897	161898	0411051	161899	0411052	161900	0411053
Sample Date	03/15/16	03/24/04	03/15/16	03/15/16	03/15/16	03/25/04	03/15/16	03/24/04	03/15/16	03/24/04
Sample Time	1100	1450	1300	1302	1455	1000	1600	1125	1700	0910
Ammonia	<0.03 ^a	<0.03 ^a	<0.03 ^a	<0.03 ^a	<0.03 ^a	<0.03 ^a	<0.03 ^a	<0.03 ^a	<0.03 ^a	<0.03 ^a
Chloride	29.0	30.2	31.4	30.9	18.2	15.0	42.3	--	26.9	22.5
Sulfate	16.9	--	15.9 ^d	15.8	14.4	--	15.9	--	14.0	--
Total Recoverable Calcium	48.4	--	47.6	48.2	43.7	--	48.4	--	43.0	--
Total Recoverable Magnesium	24.8	--	23.6	24.1	23.6	--	24.1	--	24.4	--
Hardness as CaCO ₃	223	--	216	220	206	--	220	--	208	--
Dissolved Oxygen	15.91	14.50	16.04	16.21	14.69	11.8	14.91	13.5	14.62	14.5
Discharge (cfs)	12.02	11.0	10.63	10.94	5.59	6.96	4.68	5.66	2.41	2.69
pH (Units)	9.1	8.5	8.9	9.0	8.6	7.7	9.0	8.3	8.9	8.4
Conductivity (µmhos/cm)	475	490	450	480	414	397	522	681	427	505
Temperature (°C)	15.3	14.0	16.7	17.1	18.2	14.5	18.4	13.5	19.0	12.5
Turbidity (NTU)	1.7	2.0	2.6	1.7	2.2	5.75	2.6	3.41	1.7	1.79
Total Suspended Solids	<5 ^{ab}	--	<5 ^{ab}	<5 ^{ab}	<5 ^{ab}	--	<5 ^{ab}	--	<5 ^{ab}	--
Nitrate + Nitrite-N	2.00	3.00	2.63^e	2.62^e	0.03	0.85	4.95^e	8.43	1.27	1.74
TKN	--	0.12 ^c	--	--	--	0.25	--	0.05 ^a	--	0.05 ^a
Total Nitrogen	2.45	--	2.98	3.11	0.34	--	5.41	--	1.47	--
Total Phosphorus	0.42	0.11	0.50	0.51	0.02^c	0.02^c	0.92	0.36	0.01^c	0.01 ^a

^aBelow detectable limits

^bEstimated value, QC data outside limits

^cEstimated value, detected below Practical Quantitation Limits

^dEstimated value, matrix interference

^eSample was diluted during analysis

Units mg/L unless otherwise noted. Values in bold are elevated compared to water quality standards or U.S. EPA recommended reference condition values.

5.0 Discussion

The discussion describes possible effects of stream habitat and physicochemical conditions on the biological metric scores and the macroinvertebrate community composition.

5.1 Hydrology and Land Cover

The land cover of Piper Creek, especially upstream of Town Branch, is primarily rural grassland, whereas the Town Branch watershed has a much higher percentage that is urbanized (Figure 2 and Table 2). Grassland is also the dominant land cover in the Town Branch watershed, but it also has high values for impervious surface and low intensity urban. Percent forest for the Piper Creek and Town Branch watersheds are much lower than values for the entire Ozark/Osage EDU and Dry Fork, a candidate reference stream. Elevated levels of impervious surface may have altered the hydrology of Town Branch and increased runoff (Lazaro 1990; Paul and Meyer 2001).

Multiple studies have found that elevated levels of impervious surface decrease diversity and abundance of macroinvertebrate communities compared to reference or control conditions (e.g. Cuffney et al. 2010; Paul and Meyer 2001). A USGS study of nine major metropolitan areas in the United States found that the macroinvertebrate communities declined about 9 to 23 percent at 5 percent impervious surface and 18 to 36 percent at 10 percent impervious surface compared to background conditions (Cuffney et al. 2010). The study found that the biological metrics EPTT and BI were most affected by urbanization. Cuffney et al. (2010) also found differences between metropolitan areas that had different land use before the landscape was urbanized. A much greater macroinvertebrate decline was observed in metropolitan areas that previously had been primarily forest compared to land cover that was previously mostly agriculture. Another study compared three streams with distinctly different land cover in the Piedmont region of North Carolina and found differences in the macroinvertebrate community (Lenat and Crawford 1994). This study found that a stream located in a forested watershed had a much more sensitive macroinvertebrate community with a much higher abundance and diversity of EPTT compared to a stream located in an agricultural watershed and a stream located in an urban watershed. By contrast, the agricultural stream had a much higher abundance of dipteran taxa, especially chironomids, and the urban stream had a higher abundance of oligochaete worms. Compared to reference conditions, Town Branch had an elevated percentage of urban land cover, and Piper Creek had higher percentages of agricultural and urban land cover. These land use features, in combination with the WWTF effluent, likely led to a macroinvertebrate community composed primarily of moderately tolerant or tolerant taxa.

5.2 Stream Habitat

Stream habitat assessments conducted during the fall 2015 sampling season suggest that the Piper Creek and Town Branch stations should be comparable to reference conditions in their ability to support a similar quality macroinvertebrate community (Table 3). Although the overall habitat scores were similar to reference conditions, a few metrics scored in the suboptimal or poor category. Bedrock was prevalent at Piper Creek #0.5 and Town Branch #0.9, which could have affected stream habitat metric scores for epifaunal substrate/available cover and riffle quality. Bedrock was also abundant at Town Branch #1.1 in the uppermost pool of the sampling reach. The metric that consistently had the lowest scores at most of the sampling stations was

bank vegetative protection, which had values either in the suboptimal or poor category. Riparian bank condition was also poor for both banks at Town Branch #1.1 and the right bank of Piper Creek #0.5. Lemly (1982) found that increased sediment deposition, suboptimal riffle quality, and suboptimal riparian zone width can have an effect on the macroinvertebrate community composition. Even though bedrock was abundant at some stations, vegetative protection was generally poor, and riparian zone width was poor at Town Branch #1.1, overall stream habitat scores were good and likely did not have as much effect on the MSCI scores as other factors such as land cover and nutrient enrichment from point and non-point sources.

5.3 MSCI and Biological Metrics

With the exception of Piper Creek #1.5 (the upstream control) during the fall 2015 sampling season, all of the macroinvertebrate samples during both sampling seasons from Piper Creek and Town Branch had partially supporting MSCI scores ranging from 10 to 14 when using Ozark/Osage EDU biological criteria (Table 4). Piper Creek #1.5 had a fully supporting MSCI score of 18 in fall 2015. For most Piper Creek and Town Branch samples, MSCI and biological metric scores were similar when compared to the candidate reference and BIOREF criteria. With the exception of Piper Creek #1.5, most of the individual metric scores that make up the MSCI either scored in the partially supporting or non-supporting range. The EPTT metric was very low, especially at Town Branch #0.9, and scored in the non-supporting range at the Town Branch stations during both sampling seasons. EPTT scored in the partially supporting range during the fall 2015 sampling season and in the non-supporting range during the spring 2016 sampling season at the Piper Creek test stations. The other three metrics generally scored in the partially supporting range at the test stations and the upstream control on Town Branch (Station #1.1).

A comparison of biological metrics between the 2003-2004 study and the current study showed that most of the biological metric values were similar during both sampling periods (Table 12 and 13). The only exception was at the upstream control stations on Piper Creek. The upstream Piper Creek control in 2015-2016 (station #1.5) had better metric values for EPTT, BI, and SDI than at the upstream Piper Creek control in 2003-2004 (station #2). There were also slight differences in BI at Piper Creek #1 for both sampling seasons and in EPTT during the fall sampling season at Town Branch #2 that led to slightly higher partially supporting MSCI scores in the 2003-2004 study. The similar results during both sampling periods for MSCI and biological metrics at the test stations indicate that the quality of the macroinvertebrate community in Town Branch and Piper Creek has not improved, despite the Bolivar WWTF upgrade.

5.4 Macroinvertebrate Community Composition

The macroinvertebrate community in Piper Creek and Town Branch was generally made up of more tolerant taxa than reference conditions based on the results from percent sensitive taxa, percent scrapers, scraper/filterer ratio, EPTT metrics, and the overall macroinvertebrate community composition. The only exception was at Piper Creek #1.5 (upstream control), which had much higher values for percent scrapers, scraper/filterer ratio, percent EPTT and percent Ephemeroptera than the other sampling stations. The Piper Creek #1.5 macroinvertebrate community was more similar to reference conditions compared to the downstream stations. The Piper Creek and Town Branch samples were primarily made up of moderately tolerant (BI = 5.0-

7.4) or tolerant taxa (BI = 7.5-8.9). Except at Piper Creek #1.5, the proportion of EPTT and Ephemeroptera was lower than reference conditions (Tables 6 and 8). EPTT and Ephemeroptera were especially low at Town Branch #0.9 during both sampling seasons and were much lower than reference conditions at most of the other sampling stations during the spring 2016 sampling season. Percent Trichoptera, primarily the hydropsychid caddisfly *Cheumatopsyche*, was much higher than the biological criteria reference streams during the fall 2015 sampling season at all of the sampling stations. During the spring 2016 sampling season, however, percent Trichoptera was more similar to reference conditions. Stoneflies were present in BIOREF samples during both sampling seasons, but they were absent in most Piper Creek and Town Branch samples. The only exception was Piper Creek #1.5, which had stoneflies in much lower abundance than reference conditions.

Compared to BIOREF and control stations, percent scrapers and the scraper/filterer ratio were lower during both sampling seasons, and percent filterers was higher during the fall 2016 sampling season at the Piper Creek and Town Branch test stations. Scrapers and the scraper/filterer ratio are expected to decline and filterers are expected to increase as pollution or disturbance increases (Barbour et al. 1999). Chironomidae was the most abundant family found in the samples during both sampling seasons and were especially abundant during the spring 2016 sampling season. Most of the abundant chironomid taxa found in samples had BI values in the moderately tolerant or tolerant range. These results suggest that the macroinvertebrate community in Piper Creek and Town Branch is likely affected by water quality conditions resulting from a combination of land cover and the effluent from the Bolivar WWTF. There is strong evidence based on MSCI scores and the macroinvertebrate community composition that urban land cover is affecting the macroinvertebrate community of Town Branch #1.1 (upstream control), and a combination of WWTF effluent and land cover is having an effect on the downstream test stations.

5.5 Nutrient Enrichment Effects

Results from the surface water sample analysis showed that nitrate + nitrite-N, total nitrogen, and total phosphorus were much higher than U.S. EPA recommended reference values (U.S. EPA 2000). Although nutrient levels were elevated in the present study, they were generally lower than the 2003-2004 results. This observation was most apparent when comparing fall nutrient data; spring nutrient values were more variable. With the exception of Piper Creek #1.5, MSCI scores, biological metrics, and the high abundance of moderately tolerant or tolerant taxa in Piper Creek and Town Branch indicate that nutrient concentrations are likely to be affecting the macroinvertebrate community. Based on the 2003-2004 results and the current study, there is also evidence that the nutrients originate from both point and non-point sources since nutrient levels were elevated at the upstream control stations on Piper Creek and Town Branch (Tables 16 and 17).

In studies of Midwestern streams, Wang et al. (2007) and Evans-White et al. (2009) calculated threshold values to determine at what concentrations nutrients affect macroinvertebrate communities. Wang et al. (2007) determined that TR was affected at 0.86 mg/L total nitrogen and 0.04 mg/L total phosphorus and that Hilsenhoff BI was affected at 0.61 mg/L total nitrogen and 0.09 mg/L total phosphorus. Evans-White et al. (2009) calculated that TR was affected at

1.04 mg/L total nitrogen and 0.05 mg/L total phosphorus. These threshold nutrient values are higher than the U.S. EPA recommended reference values, but they are still much lower than concentrations found in most of the Piper Creek and Town Branch samples. Other studies have found that nutrient enrichment can lead to secondary effects on macroinvertebrates such as excessive algae growth, increases in suspended fine particulate organic matter and sediment retention (Graham 1990). These effects can lead to subsequent declines in interstitial space (Broekhuizen et al. 2001) and food quality (Evans-White et al. 2009). Previous studies have also reported declines in EPTT (Dyer and Wang 2002), increases in hydropsychid caddisflies (Suckling 1982), increases in the nutrient-tolerant chironomids *Dicrotendipes* and *Cricotopus/Orthocladius* group (Jacobsen 2008), and decreases in percent scrapers and scraper/filterer ratio (Poulton et al. 2015) downstream of WWTF outfalls. Compared to BIOREF conditions, Town Branch and Piper Creek test stations had lower EPTT (especially in spring 2016), higher percent Hydropsychidae Trichoptera in fall 2015, higher *Cricotopus/Orthocladius* and *Dicrotendipes* (especially in spring 2016), lower percent scrapers and scraper/filterer ratio, and higher biotic index values for most stations (Tables 4-9).

6.0 Conclusions

With the exception of the Piper Creek upstream control (station #1.5) during the fall 2015 sampling season, Piper Creek and Town Branch MSCI scores indicate that the protection of aquatic life designated use as listed in the Missouri WQS was not being met. Low MSCI scores were likely due to land cover and nutrient enrichment that was likely caused by non-point sources at the upstream control station on Town Branch (station #1.1) and a combination of non-point and point sources at test stations downstream of the Bolivar WWTF.

Tests of the null hypotheses resulted in the following conclusions.

- 1) The macroinvertebrate community will not differ among longitudinally separate reaches of Town Branch and Piper Creek. This hypothesis was rejected since the upstream control on Piper Creek (station #1.5) had MSCI scores in fully supporting range, but the remaining downstream stations had MSCI scores in the partially supporting range using Ozark/Osage EDU biological criteria.
- 2) The macroinvertebrate assemblages in the Town Branch and Piper Creek samples will be similar to the Ozark/Osage EDU wadeable/perennial stream biological criteria. This hypothesis was rejected since all of the samples, except Piper Creek #1.5, had MSCI scores that were in the partially supporting range.
- 3) The macroinvertebrate assemblages in the Town Branch and Piper Creek samples will be similar to the Ozark/Osage EDU candidate reference stream criteria. This hypothesis was rejected since all of the samples, except the fall 2015 sample at Piper Creek #1.5, had MSCI scores that were in the partially supporting range.
- 4) Physicochemical water quality from Town Branch and Piper Creek will meet the Water Quality Standards (WQS) of Missouri (MoDNR 2014a). This hypothesis was accepted since no water quality standards were violated.

5) Physicochemical water quality will not differ among longitudinally separate reaches of Town Branch and Piper Creek. This hypothesis was rejected since water constituent results for nutrients were much lower at Piper Creek #1.5 than the other sampling stations.

6) Stream habitat at the Town Branch and Piper Creek sampling stations will be similar to Dry Fork, a candidate reference stream in the Ozark/Osage EDU. This hypothesis was accepted since the overall stream habitat assessment scores at the sampling stations were at least 75 percent of the stream habitat score of Dry Fork.

7.0 References Cited

- Barbour, M.T., J. Gerritsen, B.D. Snyder, and J.B. Stribling. (1999) Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers—Periphyton, Benthic Macroinvertebrates, and Fish. 2nd Edition, EPA 841/B-99/002, USEPA, Washington DC.
- Broekhuizen, N., S. Parkyn, and D. Miller. 2001. Fine Sediment Effects on Feeding and Growth in the Invertebrate Grazers *Potamopyrgus antipodarum* (Gastropoda, Hydrobiidae) and *Deleatidium* sp. (Ephemeroptera, Leptophlebiidae). *Hydrobiologia* 457:125-132.
- Cuffney, T.F., R.A. Brightbill, J.T May, and I.R. Waite. 2010. Responses of Benthic Macroinvertebrates to Environmental Changes Associated with Urbanization in Nine Metropolitan Areas. *Ecological Applications* 20(5):1384-1401.
- Dyer, S.D., and X. Wang. 2002. A Comparison of Stream Biological Responses to Discharges from Wastewater Treatment Plants in High and Low Population Density Areas. *Environmental Toxicology and Chemistry* 21:1065-1075.
- Evans-White, M.A., W.K. Dodds, D.G. Huggins, and D.S. Baker. 2009. Thresholds in Macroinvertebrate Biodiversity and Stoichiometry across Water-Quality Gradients in Central Plains (USA) Streams. *Journal of the North American Benthological Society* 28: 855-868.
- Graham, A.A. 1990. Siltation of Stone-Surface Periphyton in Rivers by Clay-Sized Particles from Low Concentrations in Suspension. *Hydrobiologia* 199:107-115.
- Jacobsen, R.E. 2008. Midge (Diptera: Chironomidae and Ceratopogonidae) Community Response to Canal Discharge into Everglades National Park, Florida. *Proceedings of the 16th International Chironomid Symposium* 13:39-50.
- Lazaro, T.R. 1990. *Urban Hydrology, a Multidisciplinary Perspective*. Lancaster, PA: Technomic Publishing Company.
- Lemly, D.A. 1982. Modification of Benthic Insect Communities in Polluted Streams: Combined Effects of Sedimentation and Nutrient Enrichment. *Hydrobiologia* 87:229-245.

- Lenat, D.R., and J.K Crawford. 1994. Effects of Land Use on Water Quality and Aquatic Biota of Three North Carolina Piedmont Streams. *Hydrobiologia* 294:185-199.
- Missouri Department of Natural Resources. 2002. Biological Criteria for Wadeable/Perennial Streams of Missouri. Missouri Department of Natural Resources, Environmental Services Program, P.O. Box 176, Jefferson City, Missouri 65102. 32 pp.
- Missouri Department of Natural Resources. 2003. Biological Assessment Study. Little Lindley Creek, Dallas County. Missouri Department of Natural Resources, Environmental Services Program, P.O. Box 176, Jefferson City, Missouri. 18 pp.
- Missouri Department of Natural Resources. 2005. Biological Assessment Study. Town Branch/Piper Creek, Polk County. Missouri Department of Natural Resources, Environmental Services Program, P.O. Box 176, Jefferson City, Missouri. 26 pp.
- Missouri Department of Natural Resources. 2012a. Semi-quantitative Macroinvertebrate Stream Bioassessment Project Procedure. Missouri Department of Natural Resources, Environmental Services Program, P.O. Box 176, Jefferson City, Missouri 65102. 29 pp.
- Missouri Department of Natural Resources. 2012b. Standard Operating Procedure MDNR-ESP-100: Field Analysis of Water Samples for pH. Missouri Department of Natural Resources, Environmental Services Program, P.O. Box 176, Jefferson City, Missouri 65102. 8 pp.
- Missouri Department of Natural Resources. 2013. Biological Assessment Report. Little Lindley Creek, Dallas County, Missouri. Missouri Department of Natural Resources, Environmental Services Program, P.O. Box 176, Jefferson City, Missouri. 44 pp.
- Missouri Department of Natural Resources. 2014a. Rules of Department of Natural Resources Division-Clean Water Commission, Chapter 7-Water Quality. 10 CSR 20-7.031 Water Quality Standards. pp. 12-149.
- Missouri Department of Natural Resources. 2014b. Standard Operating Procedure MDNR-ESP-002: Field Sheet and Chain-of-Custody Record. Missouri Department of Natural Resources, Environmental Services Program, P.O. Box 176, Jefferson City, Missouri 65102. 14 pp.
- Missouri Department of Natural Resources. 2015a. Quality Assurance Project Plan for Biological Assessment, LDPR Code FEBIO. State Fiscal Year 2016. Prepared by the Missouri Department of Natural Resources, Division of Environmental Quality, Water Protection Program, P.O. Box 176, Jefferson City, Missouri 65102. 21 pp.

- Missouri Department of Natural Resources. 2015b. Standard Operating Procedure MDNR-ESP-113: Flow Measurements in Open Channels. Missouri Department of Natural Resources, Environmental Services Program, P.O. Box 176, Jefferson City, Missouri 65102. 16 pp.
- Missouri Department of Natural Resources. 2016a. Standard Operating Procedure MDNR-ESP-001: Required/Recommended Containers, Volumes, Preservatives, Holding Times, and Special Sampling Considerations. Missouri Department of Natural Resources, Environmental Services Program, P.O. Box 176, Jefferson City, Missouri 65102. 27 pp.
- Missouri Department of Natural Resources. 2016b. Standard Operating Procedure MDNR-ESP-012: Analysis of Turbidity Using the Hach 2100p Portable Turbidimeter. Missouri Department of Natural Resources, Environmental Services Program, P.O. Box 176, Jefferson City, Missouri 65102. 11 pp.
- Missouri Department of Natural Resources. 2016c. Standard Operating Procedure MDNR-ESP-101: Field Measurement of Water Temperature. Missouri Department of Natural Resources, Environmental Services Program, P.O. Box 176, Jefferson City, Missouri 65102. 3 pp.
- Missouri Department of Natural Resources. 2016d. Standard Operating Procedure MDNR-ESP-102: Field Analysis for Specific Conductance. Missouri Department of Natural Resources, Environmental Services Program, P.O. Box 176, Jefferson City, Missouri 65102. 9 pp.
- Missouri Department of Natural Resources. 2016e. Standard Operating Procedure MDNR-ESP-103: Sample Collection and Field Analysis for Dissolved Oxygen Using a YSI Membrane Electrode Meter, Hach HQ40d LDO probe or YSI Pro ODO probe. Missouri Department of Natural Resources, Environmental Services Program, P.O. Box 176, Jefferson City, Missouri 65102. 11 pp.
- Missouri Department of Natural Resources. 2016f. Standard Operating Procedure MDNR-ESP-209: Taxonomic Levels for Macroinvertebrate Identifications, Environmental Services Program, P.O. Box 176, Jefferson City, Missouri 65102. 40 pp.
- Missouri Department of Natural Resources. 2016g. Standard Operating Procedure MDNR-ESP-213: Quality Control Procedures for Checking Water Quality Instruments. Missouri Department of Natural Resources, Environmental Services Program, P.O. Box 176, Jefferson City, Missouri 65102. 12 pp.
- Missouri Department of Natural Resources. 2016h. Standard Operating Procedure MDNR-ESP-214: Quality Control Procedures for Data Processing. Missouri Department of Natural Resources, Environmental Services Program, P.O. Box 176, Jefferson City, Missouri 65102. 7 pp.

- Missouri Department of Natural Resources. 2016i. Stream Habitat Assessment Project Procedure. Missouri Department of Natural Resources, Environmental Services Program, P.O. Box 176, Jefferson City, Missouri. 40 pp.
- Paul, M.J. and J.L. Meyer. 2001. Streams in the Urban Landscape. *Annual Review of Ecology and Systematics* 32: 333-365.
- Poulton, B.C., J.L. Graham, T. J. Rasmussen, and M. L. Stone. 2015. Responses of Macroinvertebrate Community Metrics to a Wastewater Discharge in the Upper Blue River of Kansas and Missouri, USA. *Journal of Water Resource and Protection* 7:1195-1220.
- Rabeni, C.F., N. Wang, and R.J. Sarver. 1999. Evaluating Adequacy of the Representative Stream Reach used in Invertebrate Monitoring Programs. *Journal of the North American Benthological Society* 18:284-291.
- Sowa, S.P., D.D. Diamond, R.A. Abbitt, G.M. Annis, T. Gordon, M.E. Morey, G.R. Sorensen, and D. True. 2004. Final Report of the Aquatic Component of GAP Analysis: A Missouri Prototype. Missouri Resource Assessment Partnership (MoRAP), University of Missouri. 111 pp.
- Sowa, S., and D. Diamond. 2006. Using GIS and an Aquatic Ecological Classification System to Classify and Map Distinct Riverine Ecosystems Throughout EPA Region 7. Missouri Resource Assessment Partnership (MoRAP), University of Missouri. 242 pp.
- Suckling, D.M. 1982. Organic Wastewater Effects on Benthic Invertebrates in the Manawatu River. *New Zealand Journal of Marine and Freshwater Research* 16:263-270.
- United States Environmental Protection Agency. 2000. Ambient Water Quality Criteria Recommendations. Information Supporting the Development of State and Tribal Nutrient Criteria for River and Streams in Nutrient Ecoregion IX. United States Environmental Protection Agency, Office of Water, Washington, D.C., EPA-822-B-00-019. 28 pp.
- United States Environmental Protection Agency. 2010. Total Maximum Load for Total Suspended Solids, Total Nitrogen, and Total Phosphorus. Piper Creek (MO_1444), Polk County, Missouri. United States Environmental Protection Agency, Region 7, Lenexa, Kansas. 143 pp.
- Wang, L, D.M. Robertson, and P.J. Garrison. 2007. Linkages Between Nutrients and Assemblages of Macroinvertebrates and Fish in Wadeable Streams: Implication to Nutrient Criteria Development. *Environmental Management* 39:194-212.

Submitted by:

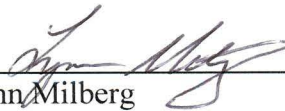


Carl Wakefield
Environmental Specialist
Water Quality Monitoring Section
Environmental Services Program

Date:

12.23.2019

Approved by:



Lynn Milberg
Chief, Water Quality Monitoring Section
Environmental Services Program

LM:cwh

c: Robert Voss, QAPP Project Manager, WPP
Cindy Davies, Southwest Regional Office

Appendix A

Piper Creek and Town Branch Macroinvertebrate Taxa Lists

Aquid Invertebrate Database Bench Sheet Report

Piper Cr [15135], Station #1.5, Sample Date: 9/21/2015 2:15:00 AM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
"HYDRACARINA"			
Acarina		4	11
AMPHIPODA			
Hyaella azteca			206
BASOMMATOPHORA			
Ancylidae	2	4	
Menetus			9
BRANCHIOBDELLIDA			
Branchiobdellida		5	
COLEOPTERA			
Berosus		-99	
Dubiraphia		15	18
Dytiscidae			2
Macronychus glabratus			1
Psephenus herricki	16	4	
Scirtidae	1		
Stenelmis	48	6	5
DECAPODA			
Faxonius luteus	-99	-99	-99
Faxonius virilis		-99	-99
DIPTERA			
Ablabesmyia	1	15	4
Ceratopogoninae	1	5	
Chironomus		2	
Cladotanytarsus		3	
Corynoneura	2		1
Cricotopus bicinctus			1
Cricotopus/Orthocladius	8	1	3
Cryptotendipes		3	
Dicrotendipes	1	2	4
Hemerodromia	7		
Labrundinia			11
Microtendipes	2	10	5
Nanocladius			5

Aquid Invertebrate Database Bench Sheet Report

Piper Cr [15135], Station #1.5, Sample Date: 9/21/2015 2:15:00 AM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Nilotanypus	5		1
Parametriocnemus	1		
Paratanytarsus		5	46
Paratendipes	1	17	
Phaenopsectra	1	1	1
Polypedilum flavum	42		
Polypedilum scalaenum grp	3	1	
Procladius		1	
Pseudochironomus			1
Rheotanytarsus	45	2	25
Simulium	4		
Stempellinella	5	4	
Stictochironomus		4	
Tabanus	1		
Tanytarsus	23	17	32
Thienemanniella	2	1	1
Thienemannimyia grp.	24		6
Tipulidae		1	
Zavreliomyia (Paramerina)			1
EPHEMEROPTERA			
Acerpenna	3		
Baetis	105		
Caenis latipennis	25	172	7
Callibaetis		1	1
Choroterpes		-99	
Heptageniidae	15		
Isonychia bicolor	4		
Leptophlebiidae	1	1	3
Maccaffertium pulchellum	30		
Procloeon			1
Stenacron	86	28	
Stenonema femoratum	5	43	1
Tricorythodes	1		
LEPIDOPTERA			
Petrophila	3		

Aquid Invertebrate Database Bench Sheet Report

Piper Cr [15135], Station #1.5, Sample Date: 9/21/2015 2:15:00 AM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
LUMBRICINA			
Lumbricina	-99		
MEGALOPTERA			
Corydalus	-99		
Sialis	1	-99	
NEOTAENIOGLOSSA			
Elimia	1	1	6
ODONATA			
Argia	11	1	6
Calopteryx			2
Enallagma			36
Epithea (Tetragoneuria)			-99
Gomphidae		1	
Hetaerina			1
PLECOPTERA			
Perlidae	2		
TRICHOPTERA			
Cheumatopsyche	107		
Chimarra	90		
Helicopsyche	2		
Hydropsyche	2		
Oecetis		1	
Triaenodes			20
TRICLADIDA			
Planariidae	11	2	
TUBIFICIDA			
Limnodrilus hoffmeisteri		1	
Tubificidae	10	23	2
VENEROIDA			
Pisidiidae	7	1	

Aquid Invertebrate Database Bench Sheet Report

Piper Cr [15134], Station #1, Sample Date: 9/21/2015 12:15:00 PM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
"HYDRACARINA"			
Acarina	1	2	
AMPHIPODA			
Hyaella azteca			5
BASOMMATOPHORA			
Ancylidae	1	13	22
Menetus		1	4
Physella		3	
BRANCHIOBDELLIDA			
Branchiobdellida	2	1	1
COLEOPTERA			
Berosus		11	7
Dubiraphia		8	3
Dytiscidae		1	
Ectopria nervosa		1	
Macronychus glabratus			3
Psephenus herricki	1	1	
Stenelmis	32	7	10
DECAPODA			
Faxonius luteus	-99		-99
Faxonius virilis	1		-99
DIPTERA			
Ablabesmyia	1	27	7
Ceratopogoninae		1	
Chironomidae		1	4
Chironomus		6	1
Chrysops	-99		
Cladotanytarsus		2	
Cricotopus bicinctus	1		
Cricotopus sylvestris grp	1	4	1
Cricotopus/Orthocladus	15	1	1
Cryptochironomus	2	9	1
Cryptotendipes		1	
Dicrotendipes		26	1
Empididae	2		

Aquid Invertebrate Database Bench Sheet Report

Piper Cr [15134], Station #1, Sample Date: 9/21/2015 12:15:00 PM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Microtendipes		5	1
Nanocladius		1	1
Nilotanypus	1	1	4
Parametriocnemus	3		
Paratanytarsus		3	12
Paratendipes		24	1
Phaenopsectra		2	
Polypedilum flavum	72	3	2
Polypedilum illinoense grp		3	1
Polypedilum scalaenum grp		6	1
Procladius		1	
Rheotanytarsus	65	1	84
Simulium	8	1	1
Stempellinella	1	1	3
Tanytarsus	11	34	22
Thienemanniella	4	1	1
Thienemannimyia grp.	21		13
Tipula	-99		
Tribelos		1	
EPHEMEROPTERA			
Baetis	54	1	
Caenis latipennis	4	92	7
Leptophlebiidae		1	
Maccaffertium pulchellum	8		
Stenacron	1	5	
Stenonema femoratum		20	
Tricorythodes	8	1	1
HEMIPTERA			
Microvelia			1
ISOPODA			
Caecidotea (Blind & Unpigmented)		1	
LUMBRICINA			
Lumbricina	-99		
LUMBRICULIDA			

Aquid Invertebrate Database Bench Sheet Report

Piper Cr [15134], Station #1, Sample Date: 9/21/2015 12:15:00 PM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Lumbriculidae		1	
NEOTAENIOGLOSSA			
Elimia	3	5	
Hydrobiidae	2	2	1
ODONATA			
Argia	1	8	26
Calopteryx			12
Enallagma			9
Hagenius brevistylus			-99
Hetaerina			9
RHYNCHOBDELLIDA			
Glossiphoniidae			-99
TRICHOPTERA			
Cheumatopsyche	307	2	2
Chimarra	3		
Hydropsyche	20		1
Hydroptila	6	1	
Triaenodes			7
TRICLADIDA			
Planariidae	13		3
TUBIFICIDA			
Limnodrilus hoffmeisteri		3	
Tubificidae	2	19	1
VENEROIDA			
Corbicula	18	10	
Pisidiidae		5	

Aquid Invertebrate Database Bench Sheet Report

Piper Cr [15133], Station #0.5, Sample Date: 9/21/2015 10:25:00 AM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
"HYDRACARINA"			
Acarina	1	2	3
AMPHIPODA			
Hyaella azteca			7
ARHYNCHOBDELLIDA			
Erpobdellidae	-99	-99	1
BASOMMATOPHORA			
Ancylidae		7	1
Menetus			10
Physella			12
COLEOPTERA			
Berosus	1	14	41
Dubiraphia	2	2	21
Ectopria nervosa		3	
Macronychus glabratus			1
Neoporus		1	11
Psephenus herricki	2		
Stenelmis	69		10
DECAPODA			
Faxonius luteus	-99	-99	
Faxonius virilis			1
DIPTERA			
Ablabesmyia	1	19	3
Chironomus		4	
Chrysops		1	
Cladotanytarsus	7	5	
Cricotopus/Orthocladius	6	3	2
Cryptochironomus	3	4	2
Dicrotendipes		22	2
Microtendipes		2	
Nanocladius			3
Nilotanypus	6		
Paratanytarsus		9	10
Paratendipes		2	4
Phaenopsectra		3	

Aquid Invertebrate Database Bench Sheet Report

Piper Cr [15133], Station #0.5, Sample Date: 9/21/2015 10:25:00 AM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Polypedilum flavum	48		
Polypedilum scalaenum grp	2	3	
Pseudosmittia			1
Rheotanytarsus	18	2	18
Simulium	3		
Stempellinella		2	1
Stictochironomus		3	
Tanytarsus	16	78	16
Thienemanniella	1	1	1
Thienemannimyia grp.	20		2
EPHEMEROPTERA			
Acentrella	1		
Baetis	78		
Caenis latipennis	8	57	3
Isonychia bicolor	1		
Maccaffertium pulchellum	4		
Stenonema femoratum		6	
Tricorythodes	36		5
HEMIPTERA			
Rheumatobates		1	
LUMBRICINA			
Lumbricina	2	-99	
LUMBRICULIDA			
Lumbriculidae			1
NEOTAENIOGLOSSA			
Elimia	2	-99	
ODONATA			
Argia	6		44
Calopteryx			9
Enallagma	5		29
Hagenius brevistylus		-99	
TRICHOPTERA			
Cheumatopsyche	206		2
Chimarra	-99		
Hydropsyche	6		

Aquid Invertebrate Database Bench Sheet Report

Piper Cr [15133], Station #0.5, Sample Date: 9/21/2015 10:25:00 AM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Hydroptila	1		
Trienodes			1
TRICLADIDA			
Planariidae	46		3
TUBIFICIDA			
Enchytraeidae	1		
Limnodrilus hoffmeisteri		2	2
Quadrilum multisetosum		1	4
Tubificidae	12	30	7
VENEROIDA			
Corbicula			-99
Pisidiidae	11	7	11

Aquid Invertebrate Database Bench Sheet Report

Town Br [15136], Station #0.9, Sample Date: 9/21/2015 4:10:00 PM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
AMPHIPODA			
Hyalella azteca		1	
BASOMMATOPHORA			
Ancylidae	2	1	30
Menetus			31
Physella		5	4
COLEOPTERA			
Berosus	6	8	2
Dytiscidae		1	
Neoporus			1
Stenelmis	11		14
DECAPODA			
Faxonius virilis	-99	-99	2
DIPTERA			
Ablabesmyia	1	21	
Chironomidae	5	6	2
Chironomus		4	1
Cladotanytarsus		3	
Corynoneura	1	1	
Cricotopus bicinctus	2		1
Cricotopus/Orthocladius	15	2	2
Cryptochironomus	2	15	1
Dasyheleinae			1
Dicrotendipes	19	59	7
Microtendipes	4	6	
Nilotanypus	1		
Parametriocnemus	3		
Paratanytarsus			4
Paratendipes		1	2
Phaenopsectra		1	1
Polypedilum flavum	174	6	20
Polypedilum illinoense grp	6		2
Polypedilum scalaenum grp		16	6
Pseudochironomus		4	1
Rheotanytarsus	16	1	4

Aquid Invertebrate Database Bench Sheet Report

Town Br [15136], Station #0.9, Sample Date: 9/21/2015 4:10:00 PM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Simulium	7		3
Tanytarsus	23	124	8
Thienemanniella	6		
Thienemannimyia grp.	48	5	10
Tipula	-99		-99
EPHEMEROPTERA			
Baetis	11		
HEMIPTERA			
Microvelia			1
LUMBRICINA			
Lumbricina	1		2
ODONATA			
Argia	3		73
Boyeria			-99
Calopteryx	1		12
Epitheca (Epicordulia)			-99
Hetaerina			5
RHYNCHOBDELLIDA			
Glossiphoniidae			-99
Piscicolidae	1		1
TRICHOPTERA			
Cheumatopsyche	145	1	5
Hydropsyche	39		4
Hydroptila	10	4	1
Oecetis			1
TRICLADIDA			
Planariidae	17	1	30
TUBIFICIDA			
Limnodrilus hoffmeisteri			1
Tubificidae	4		8
VENEROIDA			
Pisidiidae	2	3	23

Aquid Invertebrate Database Bench Sheet Report

Town Br [15137], Station #1.1, Sample Date: 9/22/2015 9:00:00 AM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
"HYDRACARINA"			
Acarina		1	
AMPHIPODA			
Gammarus			1
Hyalella azteca			3
ARHYNCHOBDELLIDA			
Erpobdellidae	1		
BASOMMATOPHORA			
Ancylidae		2	14
Menetus		2	5
Physella		3	3
BRANCHIOBDELLIDA			
Branchiobdellida		1	4
COLEOPTERA			
Dubiraphia		2	2
Dytiscidae		1	
Ectopria nervosa	2	2	1
Helichus basalis			1
Macronychus glabratus			2
Stenelmis	89	39	60
DECAPODA			
Faxonius luteus	-99	1	
Faxonius virilis	-99	-99	-99
DIPTERA			
Ablabesmyia		28	2
Chironomidae	1	1	
Chironomus		3	
Cladotanytarsus	7	17	2
Corynoneura	4		
Cricotopus sylvestris grp	3	4	
Cricotopus/Orthocladius	14	3	2
Cryptochironomus	4	5	2
Dicrotendipes	5	19	3
Diptera		2	
Microtendipes	2	13	

Aquid Invertebrate Database Bench Sheet Report

Town Br [15137], Station #1.1, Sample Date: 9/22/2015 9:00:00 AM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Nilotanypus	9	1	6
Parametriocnemus	4		1
Paratanytarsus	3	9	14
Paratendipes		12	9
Phaenopsectra		1	1
Polypedilum aviceps	4		
Polypedilum flavum	116	3	4
Polypedilum scalaenum grp		13	3
Rheotanytarsus	27		15
Simulium	28		
Stenochironomus	1		2
Tanytarsus	43	52	17
Thienemanniella	16	1	
Thienemannimyia grp.	25	1	7
Tipula	1		1
Zavrelimyia		1	
EPHEMEROPTERA			
Baetis	254	1	1
Maccaffertium pulchellum	2		
Stenacron	5	3	1
Stenonema femoratum		3	
HAPLOTAXIDA			
Haplotaxis	1	2	
LEPIDOPTERA			
Petrophila	7	1	
LUMBRICINA			
Lumbricina	11	1	-99
ODONATA			
Argia	12	1	58
Calopteryx	3	2	37
Hetaerina	2	2	9
TRICHOPTERA			
Cheumatopsyche	116		2
Chimarra	82		
Hydropsyche	12		

Aquid Invertebrate Database Bench Sheet Report

Town Br [15137], Station #1.1, Sample Date: 9/22/2015 9:00:00 AM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Hydroptila	1		
TRICLADIDA			
Planariidae	28		4
TUBIFICIDA			
Enchytraeidae	1		
Tubificidae	1	28	9
VENEROIDA			
Pisidiidae		1	1

Aquid Invertebrate Database Bench Sheet Report

Piper Cr [16050], Station #0.5, Sample Date: 3/15/2016 11:05:00 AM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
"HYDRACARINA"			
Acarina	1	2	1
AMPHIPODA			
Crangonyx	-99		
ARHYNCHOBDSELLIDA			
Erpobdellidae	2	-99	1
COLEOPTERA			
Berosus		1	5
Dubiraphia		1	1
Dytiscidae		4	
Ectopria nervosa	1		
Laccophilus			5
Stenelmis	17	3	3
DIPTERA			
Ablabesmyia		1	1
Ceratopogoninae		4	
Chironomidae	1	5	
Chironomus	2	3	
Cladotanytarsus	1	10	1
Cricotopus trifascia			1
Cricotopus/Orthocladius	190	42	116
Cryptochironomus	1	2	
Cryptotendipes	1	1	
Dicrotendipes	19	67	17
Diptera	1		
Eukiefferiella	271	12	87
Hydrobaenus	10	16	8
Micropsectra	12	3	21
Microtendipes		4	
Nanocladius		1	
Nilotanypus	8		
Ormosia			1
Orthocladius (Euorthocladius)			1
Parakiefferiella		1	
Parametriocnemus	2		

Aquid Invertebrate Database Bench Sheet Report

Piper Cr [16050], Station #0.5, Sample Date: 3/15/2016 11:05:00 AM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Paratanytarsus		3	1
Paratendipes	1	26	1
Phaenopsectra		2	
Polypedilum aviceps	11		3
Polypedilum flavum	25	1	1
Polypedilum illinoense grp	14	2	39
Polypedilum scalaenum grp	11	9	1
Polypedilum tritum			2
Pseudochironomus		7	
Psychoda		3	
Rheocricotopus	1		
Rheotanytarsus	12		14
Simulium	2		1
Stempellinella	1		
Sympotthastia	1		
Tanytarsus	42	29	19
Thienemanniella		1	2
Thienemannimyia grp.	18	1	9
Zavreliomyia		1	
EPHEMEROPTERA			
Baetis	1		
Caenis latipennis	1	1	
Maccaffertium terminatum	1		
Stenacron	1		
Stenonema femoratum	1		
HEMIPTERA			
Microvelia			1
LUMBRICINA			
Lumbricina	-99	-99	
NEOTAENIOGLOSSA			
Elimia	1	1	2
ODONATA			
Gomphidae		1	
Hetaerina			-99
TRICHOPTERA			

Aquid Invertebrate Database Bench Sheet Report

Piper Cr [16050], Station #0.5, Sample Date: 3/15/2016 11:05:00 AM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Cheumatopsyche	6		4
Hydropsyche			1
Hydroptila	6		5
TRICLADIDA			
Planariidae	4	2	4
TUBIFICIDA			
Enchytraeidae		4	
Limnodrilus hoffmeisteri		12	1
Tubificidae	2	25	1

Aquid Invertebrate Database Bench Sheet Report

Piper Cr [16051], Station #1a, Sample Date: 3/15/2016 1:15:00 PM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
"HYDRACARINA"			
Acarina		1	1
ARHYNCHOBDELLIDA			
Erpobdellidae	-99		
BASOMMATOPHORA			
Ancylidae			5
Menetus			2
Physella	1		
BRANCHIOBDELLIDA			
Branchiobdellida	1		6
COLEOPTERA			
Ancyronyx variegatus		1	
Berosus			4
Dubiraphia	1	1	2
Dytiscus	1		1
Ectopria nervosa	1		
Macronychus glabratus			1
Psephenus herricki		1	
Stenelmis	22	5	9
DECAPODA			
Faxonius luteus	-99		-99
Faxonius virilis			-99
DIPTERA			
Ablabesmyia	1	4	11
Chaetocladius	1		
Chironomidae		25	4
Chironomus	1	9	1
Cladotanytarsus	1		
Cricotopus bicinctus	5	1	4
Cricotopus trifascia	1		1
Cricotopus/Orthocladius	241	36	43
Cryptochironomus	3	2	
Dicrotendipes	21	89	14
Diplocladius	1		
Ephydriidae	1		

Aquid Invertebrate Database Bench Sheet Report

Piper Cr [16051], Station #1a, Sample Date: 3/15/2016 1:15:00 PM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Eukiefferiella	107	2	4
Hemerodromia		1	
Hydrobaenus	4	7	12
Labrundinia			1
Micropsectra	10	3	9
Microtendipes		3	
Nanocladius		1	7
Nilotanypus			2
Parametriocnemus			1
Paraphaenocladius	3		
Paratanytarsus			11
Paratendipes	5	46	4
Phaenopsectra			2
Polypedilum aviceps	13		
Polypedilum fallax grp	1	1	
Polypedilum flavum	15		
Polypedilum halterale grp		1	
Polypedilum illinoense grp	16		10
Polypedilum scalaenum grp	20	36	
Pseudochironomus	1	1	
Psychoda	1	1	
Rheotanytarsus	13		39
Stempellinella		1	
Tanytarsus	56	20	48
Thienemanniella	2		
Thienemannimyia grp.	37	2	40
Tipula	1		-99
Tvetenia bavarica grp	1		
Zavrelimyia (Paramerina)		1	
EPHEMEROPTERA			
Caenis latipennis	2	7	2
Stenonema femoratum	2		
LUMBRICINA			
Lumbricina	1		
LUMBRICULIDA			

Aquid Invertebrate Database Bench Sheet Report

Piper Cr [16051], Station #1a, Sample Date: 3/15/2016 1:15:00 PM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Lumbriculidae			5
ODONATA			
Argia			8
Calopteryx			9
Enallagma			14
Macromia			-99
TRICHOPTERA			
Cheumatopsyche	5		7
Hydropsyche	2		1
Hydroptila	6		5
Oecetis			2
Pycnopsyche			-99
TRICLADIDA			
Planariidae	2		1
TUBIFICIDA			
Enchytraeidae	2		
Limnodrilus hoffmeisteri		1	
Tubificidae	1	10	1
VENEROIDA			
Pisidiidae	1	1	1

Aquid Invertebrate Database Bench Sheet Report

Piper Cr [16052], Station #1b, Sample Date: 3/15/2016 1:15:00 PM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
AMPHIPODA			
Crangonyx			1
BASOMMATOPHORA			
Ancylidae		1	3
Menetus			2
Physella			-99
COLEOPTERA			
Ancyronyx variegatus			1
Berosus			1
Dubiraphia		2	2
Macronychus glabratus			2
Psephenus herricki	1		
Stenelmis	40	6	4
DECAPODA			
Faxonius luteus			-99
Faxonius virilis			-99
DIPTERA			
Ablabesmyia	1	12	10
Brillia	1		
Chaetocladius		2	
Chironomidae	1	17	
Chironomus		6	3
Chrysops		-99	
Cladotanytarsus	1		
Corynoneura	1		1
Cricotopus bicinctus		1	5
Cricotopus trifascia	3		
Cricotopus/Orthocladius	230	28	49
Cryptochironomus	2		1
Diamesa	1		
Dicrotendipes	12	55	25
Diptera		1	
Eukiefferiella	112	4	
Hydrobaenus	4	9	7
Micropsectra	7	4	14

Aquid Invertebrate Database Bench Sheet Report

Piper Cr [16052], Station #1b, Sample Date: 3/15/2016 1:15:00 PM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Microtendipes		1	1
Nanocladius			1
Nilotanypus	9		3
Parametriocnemus	3	1	1
Paratanytarsus	2	4	8
Paratendipes	14	37	8
Phaenopsectra	2	1	3
Polypedilum aviceps	5		
Polypedilum fallax grp	8		1
Polypedilum flavum	8		
Polypedilum halterale grp		1	
Polypedilum illinoense grp	17		7
Polypedilum scalaenum grp	19	37	1
Pseudochironomus			1
Psychoda	1	2	
Rheotanytarsus	13	1	42
Simulium	4		
Stempellinella	1		
Tanytarsus	35	22	21
Thienemanniella	2		1
Thienemannimyia grp.	41	1	33
Tipula		-99	
Tvetenia bavarica grp	2		
EPHEMEROPTERA			
Acerpenna	-99		
Caenis latipennis		2	9
Stenonema femoratum	-99	1	
LUMBRICINA			
Lumbricina		-99	
NEOTAENIOGLOSSA			
Elimia			4
ODONATA			
Argia		1	6
Calopteryx	-99		13
Enallagma			16

Aquid Invertebrate Database Bench Sheet Report

Piper Cr [16052], Station #1b, Sample Date: 3/15/2016 1:15:00 PM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Hagenius brevistylus			-99
Perithemis			1
TRICHOPTERA			
Cheumatopsyche	9		8
Hydropsyche	2	1	1
Hydroptila	15	12	1
Oecetis			1
Ptilostomis			-99
Pycnopsyche			-99
Triaenodes			4
TRICLADIDA			
Planariidae	5	1	
TUBIFICIDA			
Enchytraeidae	1		
Limnodrilus hoffmeisteri		1	1
Tubificidae	1	16	2
VENEROIDA			
Pisidiidae	1	1	1

Aquid Invertebrate Database Bench Sheet Report

Piper Cr [16053], Station #1.5, Sample Date: 3/15/2016 2:55:00 PM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
"HYDRACARINA"			
Acarina	8	10	3
AMPHIPODA			
Hyaella azteca			8
ARHYNCHOBDELLIDA			
Erpobdellidae	-99		-99
BASOMMATOPHORA			
Lymnaeidae			1
Menetus			3
Physella			-99
COLEOPTERA			
Agabus			3
Berosus		1	
Dubiraphia		5	24
Dytiscidae		4	
Ectopria nervosa			1
Macronychus glabratus			5
Psephenus herricki	4		
Stenelmis	120	4	24
DECAPODA			
Faxonius luteus	1		-99
Faxonius virilis			1
DIPTERA			
Ablabesmyia	1	3	1
Ceratopogoninae	3	2	5
Chironomidae	1	1	5
Chironomus		2	
Cladotanytarsus		7	
Clinocera	7		
Cricotopus/Orthocladius	38	5	14
Cryptochironomus		4	2
Cryptotendipes		2	
Dicrotendipes	1	5	5
Ephydriidae		1	
Eukiefferiella	125	7	23

Aquid Invertebrate Database Bench Sheet Report

Piper Cr [16053], Station #1.5, Sample Date: 3/15/2016 2:55:00 PM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Hemerodromia	5		
Hydrobaenus		1	
Labrundinia			6
Micropsectra	1	4	7
Nanocladius			2
Nilotanypus	1		
Nilothauma		2	
Paralauterborniella			1
Parametriocnemus	5		1
Paratanytarsus	1	2	19
Paratendipes	3	97	13
Phaenopsectra	1		1
Polypedilum aviceps	7		1
Polypedilum fallax grp	3		2
Polypedilum halterale grp		1	
Polypedilum illinoense grp	7	4	27
Polypedilum scalaenum grp	9	10	3
Polypedilum tritum			4
Rheotanytarsus	34	2	23
Simulium	5		
Stempellinella	1	1	
Tabanus	-99		
Tanytarsus	34	24	40
Thienemanniella	1		3
Thienemannimyia grp.	65	1	25
Tvetenia bavarica grp	1		
EPHEMEROPTERA			
Acerpenna	5		
Caenis latipennis	68	38	66
Centroptilum			1
Isonychia bicolor	2		
Maccaffertium pulchellum	9		
Stenacron	20	1	1
Stenonema femoratum	11	3	3

GORDIOIDEA

Aquid Invertebrate Database Bench Sheet Report

Piper Cr [16053], Station #1.5, Sample Date: 3/15/2016 2:55:00 PM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Gordiidae	1		
HEMIPTERA			
Belostoma			-99
LUMBRICINA			
Lumbricina	-99		
MEGALOPTERA			
Corydalus	2		
NEOTAENIOGLOSSA			
Elimia	-99		6
ODONATA			
Argia			4
Basiaeschna janata			1
Calopteryx			2
Enallagma	1		26
Hetaerina			2
Nasiaeschna pentacantha			-99
PLECOPTERA			
Amphinemura	1		
Perlesta	21		1
TRICHOPTERA			
Cheumatopsyche	6		2
Chimarra	9		
Helicopsyche	2		2
Hydropsyche	2		
Hydroptila	3		1
Nyctiophylax	1		
Oecetis			1
Pycnopsyche			-99
Triaenodes			5
TRICLADIDA			
Planariidae	6		
TUBIFICIDA			
Limnodrilus hoffmeisteri	5	4	2
Tubificidae	15	13	4
VENEROIDA			

Aquid Invertebrate Database Bench Sheet Report

Piper Cr [16053], Station #1.5, Sample Date: 3/15/2016 2:55:00 PM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Corbicula			-99
Pisidiidae	1		6

Aquid Invertebrate Database Bench Sheet Report

Town Br [16054], Station #0.9, Sample Date: 3/15/2016 4:00:00 PM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
ARHYNCHOBDELLIDA			
Erpobdellidae	1	-99	
BASOMMATOPHORA			
Ancylidae	2	1	2
Menetus		2	1
Physella		1	6
COLEOPTERA			
Berosus		1	
Dytiscus			1
Macronychus glabratus			1
Peltodytes		1	
Stenelmis	11	1	4
DECAPODA			
Faxonius virilis			-99
DIPTERA			
Brillia	1	1	1
Chironomidae	1	3	2
Chironomus	2	6	3
Cladotanytarsus		3	
Cricotopus bicinctus	10		9
Cricotopus/Orthocladius	478	99	181
Cryptochironomus	1		
Dicrotendipes	30	118	68
Diptera		3	
Eukiefferiella	3		
Hydrobaenus		4	1
Micropsectra	4	3	5
Microtendipes		3	
Nilotanypus	1		
Paratendipes	1		
Phaenopsectra	1	1	
Polypedilum aviceps	4		
Polypedilum flavum	8		1
Polypedilum illinoense grp	6	4	8
Polypedilum scalaenum grp	7	11	

Aquid Invertebrate Database Bench Sheet Report

Town Br [16054], Station #0.9, Sample Date: 3/15/2016 4:00:00 PM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Pseudochironomus	2	10	
Psychoda	1	11	2
Simulium	3		
Tanytarsus	12	8	22
Thienemanniella	3		4
Thienemannimyia grp.	4	1	4
Tipula			-99
Tvetenia bavarica grp	1		1
LUMBRICINA			
Lumbricina	1		
LUMBRICULIDA			
Lumbriculidae			1
ODONATA			
Argia			2
Calopteryx			4
Enallagma			1
TRICHOPTERA			
Cheumatopsyche	4		4
Hydropsyche	13	-99	2
Hydroptila	23	4	2
TRICLADIDA			
Planariidae	9	1	14
TUBIFICIDA			
Enchytraeidae	1		
Limnodrilus claparedianus		2	
Limnodrilus hoffmeisteri		2	
Tubificidae	15	7	
VENEROIDA			
Pisidiidae		2	

Aquid Invertebrate Database Bench Sheet Report

Town Br [16055], Station #1.1, Sample Date: 3/15/2016 5:00:00 PM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
"HYDRACARINA"			
Acarina		2	
AMPHIPODA			
Crangonyx	6	2	2
Hyalella azteca			-99
ARHYNCHOBDELLIDA			
Erpobdellidae	-99	-99	
BASOMMATOPHORA			
Ancylidae	1		
Menetus			2
Physella			2
BRANCHIOBDELLIDA			
Branchiobdellida			2
COLEOPTERA			
Ectopria nervosa		1	
Macronychus glabratus			2
Stenelmis	88	6	6
DECAPODA			
Faxonius virilis			-99
DIPTERA			
Ablabesmyia		4	1
Brillia	1	2	1
Chironomidae		5	3
Cladotanytarsus	5	2	
Corynoneura		1	
Cricotopus bicinctus	13		2
Cricotopus/Orthocladius	344	10	17
Diamesa	1		
Dicrotendipes	18	177	86
Diptera	1	7	
Eukiefferiella	55	2	1
Hemerodromia	1		
Hydrobaenus		5	
Micropsectra		2	3
Microtendipes	3	2	1

Aquid Invertebrate Database Bench Sheet Report

Town Br [16055], Station #1.1, Sample Date: 3/15/2016 5:00:00 PM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Parametriocnemus	4		
Paratanytarsus		1	17
Paratendipes		9	1
Phaenopsectra			2
Polypedilum aviceps	41		2
Polypedilum flavum	1		
Polypedilum illinoense grp	2		4
Polypedilum scalaenum grp	9	31	4
Pseudosmittia			1
Psychoda	1		
Rheotanytarsus	7	1	11
Simulium	5	1	
Stenochironomus			1
Tanytarsus	29	25	65
Thienemannimyia grp.	14		5
Tipula	-99		
Tribelos			1
Tvetenia bavarica grp	13		1
EPHEMEROPTERA			
Baetis	2		
Caenis latipennis			2
Stenacron	1		
LEPIDOPTERA			
Petrophila	1		
LUMBRICINA			
Lumbricina	6		
ODONATA			
Argia	3		7
Calopteryx			17
Enallagma			13
TRICHOPTERA			
Cheumatopsyche	4	-99	4
Chimarra	3		
Hydropsyche	3		
Hydroptila			1

Aquid Invertebrate Database Bench Sheet Report

Town Br [16055], Station #1.1, Sample Date: 3/15/2016 5:00:00 PM

CS = Coarse; NF = Nonflow; RM = Rootmat; -99 = Presence

ORDER: TAXA	CS	NF	RM
Triaenodes			1
TRICLADIDA			
Planariidae	23		2
TUBIFICIDA			
Enchytraeidae	1		
Limnodrilus hoffmeisteri		1	
Tubificidae	1	6	32